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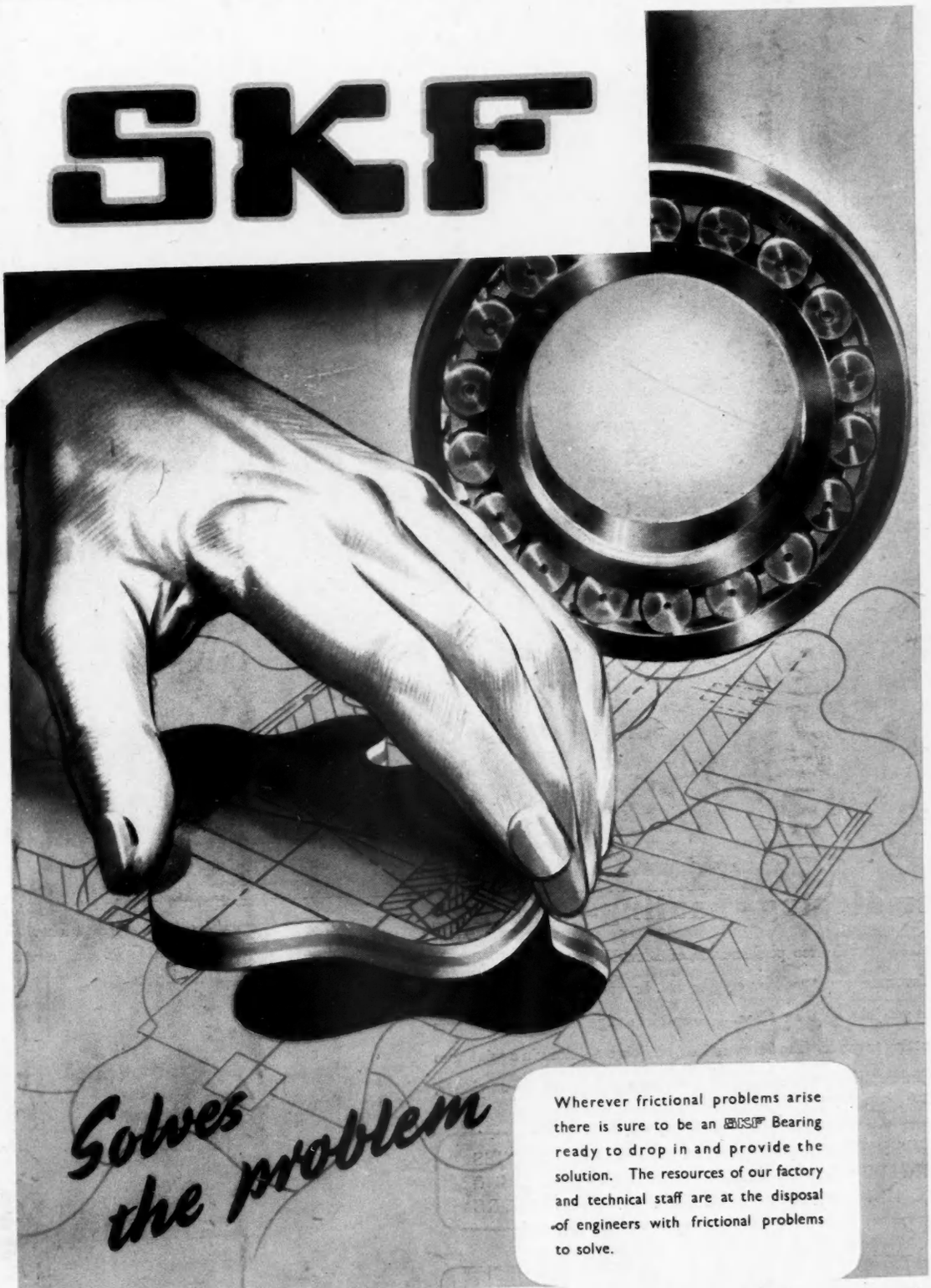

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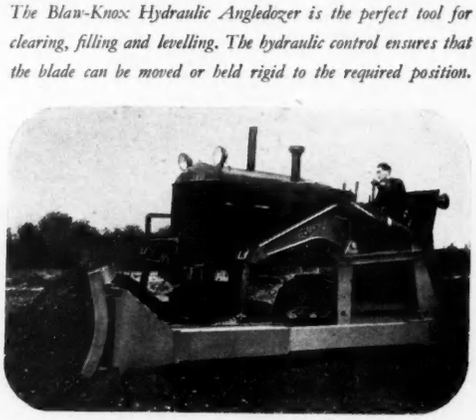

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The Engineer

LONDON, FRIDAY, DECEMBER 24, 1943.

PUBLIC NOTICES

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plicants should write to the MINISTRY OF OUR AND NATIONAL SERVICE, CEN-L (TECHNICAL AND SCIENTIFIC) ISTER, ADVERTISING SECTION, ALEX-RA HOUSE, KINGSWAY, LONDON, 2, for the necessary forms of application, ing reference number E.836 A. 8740

SITUATIONS OPEN

ES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

the benefit of applicants, the Proprietors pared to insert brief notices that vacancies filled, upon receipt of notifications from the rtisers. These notices (limited to one line) be free of charge, and co-operation is ed for.

IMPORTANT

rtisers in Situations Open Column uld make themselves acquainted with terms of

STATUTORY RULES & ORDERS 1941 No. 2069

TRICTION ON ENGAGEMENT ORDER

IEF ENGINEER for Large Chemical Works ar London, to Take Charge of Installation, enance, and Mechanical Running of Plant, ther with the Upkeep of all Services. Some trial Experience preferred. Position would ermanent and progressive. Salary commen-te with the position and according to quali-ions. Applicants should be qualified engi-, and should be between the ages of 35 and -Applicants should write to the MINISTRY LABOUR AND NATIONAL SERVICE, al (Technical and Scientific) Register, rtising Section, Alexandra House, Kings-, London, W.C.2, for the necessary forms. reference number C.1869 XA must be quoted. 8730 A

IEF PLANNING ENGINEER REQUIRED by well-known Airframe Manufacturing rn in London area ; must be conversant latest methods of Quantity Production and D procedure ; knowledge of Rate-fixing and ury Systems essential. Opening is for first-man only and salary up to £1000 per m would be paid.

pplicants should write to the MINISTRY OF OUR AND NATIONAL SERVICE, Central hnical and Scientific) Register, Advertising ion, Alexandra House, Kingsway, London, 2, for the necessary forms. The reference ber C.1951 XA must be quoted. 8724 A

RANE WORKS REQUIRE MANAGER to Take Control of Production. Only fully lified man with Works Management experi-e will be considered.—Applications to be made writing to JOSEPH BOOTH and BROS., on Crane Works, Rodley, Leeds. Envelopes be endorsed "Application for Manager." 8708 A

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The Engineer

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HYDROJET ASH & DUST SLUICING BABCOCK & WILCOX LTD.

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THE FACT that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

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FACTORY MANAGER REQUIRED for Engineering establishment in Essex, production shop and tool-room for Metal and Plastic ; must have extensive knowledge and experience of administration, conversant with modern methods, estimating, process planning, and time study.—Address, 8725, The Engineer Office. 8725 A

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SITUATIONS OPEN

SCIAKY ELECTRIC WELDING MACHINES, Ltd., Slough, Makers of High-Grade Resistance Welding Machines, invite APPLICATIONS for REPRESENTATIVE for the Midland Counties. Must have experience of Resistance Welding Machines and their application. Sound post-war prospects.—Write, full particulars, experience, remuneration, &c. 8713 A

THE Post You Are Seeking May Not Be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

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IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 6s.; each Additional Line, 1s. 6d. Box Numbers 1s. extra, which includes despatch of all replies.

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The Engineer

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Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

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For continuation of Small Adverts see page 52

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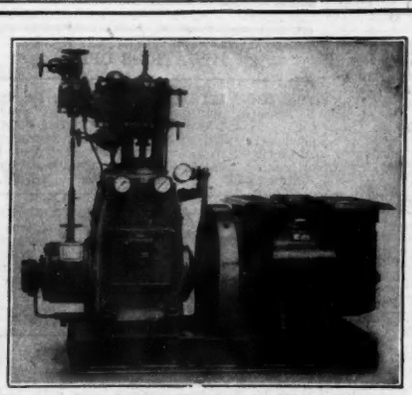

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A Seven-Day Journal

Ministry of Supply Changes

IT is announced by the Ministry of Supply that Mr. A. J. Boyd is relinquishing his appointment as Director-General of Fighting Vehicles Production on his return to his company, the Metropolitan-Cammell Carriage and Wagon Company, Ltd., at the end of the year. It will be recalled that Mr. Boyd was appointed in October, 1942, under Commander E. R. Micklem, R.N., of Vickers-Armstrongs, Ltd., who was released by his company to become Chairman of the Armoured Fighting Vehicles Division and Chairman of the Tank Board of the Ministry of Supply, Mr. Oliver Lucas retaining his position of Director-General of Armoured Vehicles Design. Mr. C. D. Gibb, of C. A. Parsons and Co., Ltd., has been appointed to succeed Mr. Boyd. It is announced that Mr. Gibb, as Director-General of Armoured Fighting Vehicles, will be responsible for both the design and production branches. In a further announcement by the Ministry, it is stated that Mr. K. Headlam-Morley has resigned from the position of Deputy Controller of the Chrome Ore, Magnesite, and Wolfram Control, and has accepted an honorary appointment in a consultative capacity with the Iron and Steel Control. Mr. Headlam-Morley will continue to act as the Secretary of the Iron and Steel Institute.

The Organisation of the Coal Industry

DURING the week which has just ended the Minister of Fuel and Power, Major Lloyd George, has discussed with the Mineworkers' Association and the Mining Association his proposals for the efficient organisation of the coal industry for production under wartime conditions. In an official announcement made on Tuesday, December 21st, it was stated by the Minister that the discussion which took place covered certain proposals made by the Ministry as to the means for giving effect to the conclusions of the Government's review of its wartime control. The representatives of the Mineworkers' Federation submitted their views on the proposals of the Minister that all pits within each region should be segregated into groups, each group being under the supervision of a group production director, who would be a State servant and a mining engineer of proved ability, would be appointed by the Minister and would report to the Regional Controller. The Federation representatives accepted the proposals in principle, but made the suggestion that there should also be a group labour officer for each group. The question of man power was also discussed, and again the men's representatives pressed for the return of ex-miners from the Services and other war industries. Major Lloyd George drew attention to the fact that over 60,000 men had been returned to the industry from these sources during the last two years, and more were to come, but beyond the present scheme for return from the Army it was the definite policy of the Government, he said, that withdrawals of trained Service men in other industries could not be permitted at the present juncture.

The Rating of Railways

AFTER hearing and determining representations, it is announced by the Railway Assessment Authority that it has now completed the part of the third railway valuation roll which relates to the Southern Railway Company. The new figures entered on the roll, which are open to appeal, will operate for the five rating years from 1941 to 1946, and the sum of £1,339,806 is given as the total net value of the company's undertaking as a whole, that figure being about 16½ per cent. larger than the total given on the second roll. It is further announced by the Authority that it has rejected the representation made on behalf of the London County Council, which suggested that the sum of £1,339,806 was not estimated according to the statutory provisions, was incorrect and inadequate, and should be altered to £3,300,000. With regard to the London Passenger Transport Board, the Authority has agreed with that undertaking to enter a net annual value for the period above mentioned, 1941 to 1946, of £850,000, which sum may be compared with that of £945,270, which was determined by the Railway and Canal Commission for the first London Transport roll. The items included in the undertaking include the Board's transport undertaking, embracing the tubes and underground railways and the trolleybus system, but excluding the properties connected with the omnibus side of the business. A written statement recounting the circumstances in which for each of the amalgamated railways the Authority and the companies have come to an agreement on a net value *in cumulo*, which, in general, involves a net increase of about 16½ per cent., can be obtained for 1s., postage extra, from the Railway Assessment Authority, at 32, Queen Anne's Gate, London, S.W.1.

The Forth Road Bridge Scheme

IN a Journal note of February 12th we recorded the decision of the Advisory Committee in Edinburgh, following a conference of local authorities, to go forward with the approved scheme of building a road bridge across the Firth of Forth at the Mackintosh Rock site, a little west of the railway bridge. At a meeting of the Committee, which took place on Tuesday, December 21st, a new scheme was put forward by Lord Elgin, who submitted a memorandum to the Committee. It was unanimously approved that Lord Elgin's proposals should be referred to the Committee's engineers and reported upon. The new scheme takes the form of a suspension bridge, having a length of about half a mile. There would be two main spans, each of 2400ft., which would be arranged close to the existing railway bridge on its east side. The distance between the two bridges would vary from 400ft. to 1200ft. at the end of the spans, and the central pier of the new bridge would be on the island of Inchgarvie, which also supports the main pier of the railway bridge. The advantages claimed by Lord Elgin are that navigation facilities are better, since the central pier is on the island of Inchgarvie, while the other main piers would be outside the navigation channel. The connection to the Edinburgh road would only require a short approach. Compared with the Mackintosh Rock scheme, which would span the River Forth between Port Edgar and North Queensferry, about a mile west of the railway bridge, Lord Elgin contends that if it can be assumed that the two bridges are to be designed on the same basis, his own scheme would be slightly cheaper than the other scheme. The estimated cost of the Mackintosh Rock site scheme, before the war, was about £3,260,000.

International Labour Organisation

THE possibility of the International Labour Office performing a useful function by bringing together people of different countries through their specialised occupations was suggested by Sir Frederick Leggett in a statement made on behalf of the British Government at a session of the Governing Body of the International Labour Office, held in London on Saturday, December 18th. Sir Frederick said that there was an affinity between men and women engaged in the same occupation, irrespective of race, creed, and other considerations. It was realised in Britain that there was a strong necessity to encourage voluntary organisations of employers and workers in order to give maximum self-government in industry, to the advantage of Britain and the world in general. He suggested that the International Labour Office might by its efforts bring together employers and workers in the coal, iron and steel, engineering, building and civil engineering, textile, and transport industries. He felt sure, he said, that the greatest benefit would result from employers and workers themselves dealing with each other internationally, as they now did in national industry. It was agreed that a further meeting of the Joint Maritime Commission should be called next year in order to discuss the demands of international organisations of seafarers for minimum international standards to cover pay, leave, subsistance allowances, social insurance, unemployment, sickness, pensions, and loss of effects. A conference has put forward a suggestion that penalties should be imposed if agreed standards are not conformed with. An international seamen's charter is now being discussed in Washington, and its code will cover such important matters as improved accommodation and safety of life at sea.

University Research Grants

LAST week Mr. Attlee, the Deputy Prime Minister, who was accompanied by Lord Cherwell, Sir John Anderson, and Sir William Jowitt, received a deputation from the Parliamentary and Scientific Committee, which urged the Government to expand university education and research. The deputation, which was led by Lord Samuel, included Members of Parliament, professors, peers, and technical experts. It strongly urged the Government to give more direct encouragement to both scientific and technical training and to research, which it regards as an essential part in the plans now being considered, for the promotion of industrial reconstruction after the war. Mr. E. W. Salt, the Chairman of the Committee, asked the Minister for an additional grant of £1,000,000 for the universities so that they could begin to extend their scientific work. He also suggested that a full day's debate on science and industry in the House of Commons might well be arranged. In his reply Mr. Attlee said that the existence of the Committee and its work indicated the desire for more science in our national affairs, but if the Government was to play its part there must be an equal interest and activity on the part of industry and the public. Sir John Anderson, the Chancellor of the Exchequer, said that he would welcome concrete recommendations before the Budget as to the effect of taxation upon private industrial research. Arrangements had, he said, already been made to reconstitute and enlarge the University Grants Committee. It was, he concluded, in the interest of the Treasury that research should be encouraged in so far as it would increase the wealth and efficiency of industry.

Development of Open-Cast Mining

IN his chairman's address at the recent annual meeting of Sir Lindsay Parkinson and Co., Ltd., Lieut.-Colonel G. W. Parkinson stated that he had reason to believe that his firm had gained four records since the war started. It had done more work than any other firm of contractors; it had completed the largest building contract ever undertaken either in this country or abroad by one firm, and the speed of construction maintained during the job had created a world record. Colonel Parkinson then went on to speak of his own initiative in bringing to the notice of the Government the possibilities to be derived from open-cast mining. At the present time, he went on to say, the bulk of the company's plant was engaged in open-cast mining, which marked the firm's fourth record. The company had already produced by this means more than 1,150,000 tons of coal. This year the Ministry of Fuel and Power was expecting to produce no less than 15,000,000 tons from open-cast mining. The firm had begun outcrop mining alone, but at the present time there were more than fifty contractors engaged in the project. As regards the future, taking the long view, Colonel Parkinson said that there were excellent prospects ahead, in building, civil engineering, and in road construction. During the present war the company had worked, not as a private concern, but as a branch of a Government Department. He appreciated that some form of control had to exist when the war was over, but it was incumbent upon contractors as a whole to put their house in order so that they could demand the removal after the war of all those irksome rules and regulations which only tended to stifle private enterprise.

Engineers and the British Empire

By Professor MIDDLETON SMITH, M.Sc., M.I.Mech. E., LL.D.

No. XXV—(*Continued from page 480, December 17th*)

The Colonial Empire

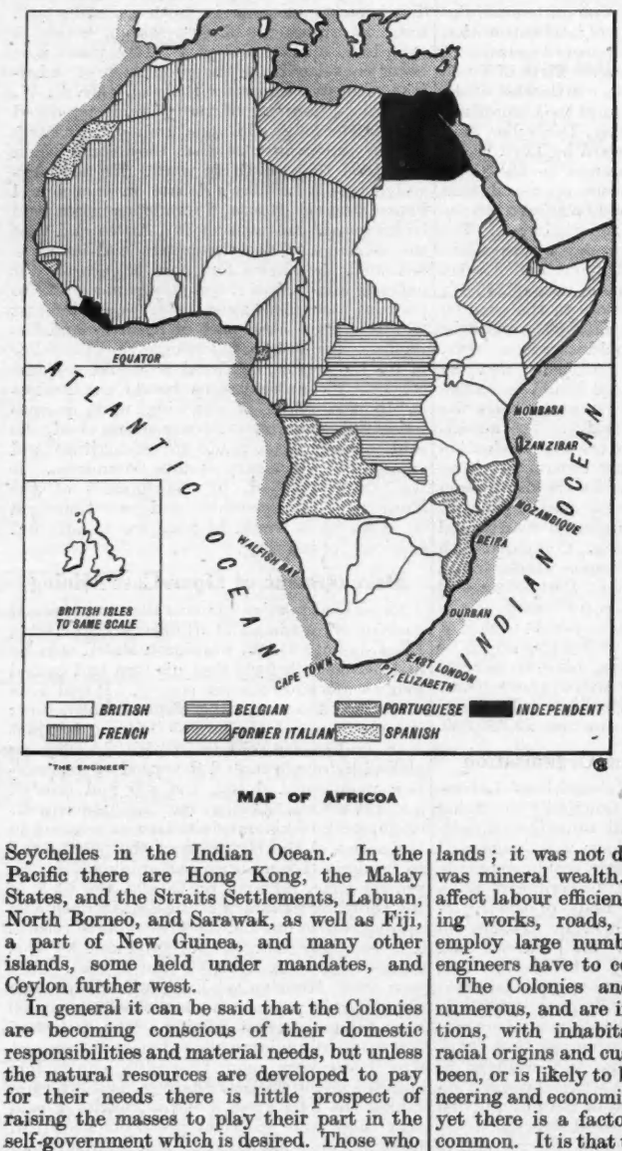
THE British Empire is oceanic in origin and is remarkable for its geographical distribution. There are the strategical places, such as Gibraltar, Malta, Cyprus, and Aden. In the Americas there are included in the Empire Newfoundland and Labrador, British Guiana, Honduras, the Falkland Islands, and the Bermudas, as well as the West Indian Islands, of which the most important are Jamaica, the Bahamas, and Trinidad. In Africa there are Nigeria, Gambia, Sierra Leone, and the Gold Coast, as well as Kenya, various Protectorates and Mandated Territories, on the East Coast, with Mauritius and Seychelles in the Indian Ocean. In the Pacific there are Hong Kong, the Malay States, and the Straits Settlements, Labuan, North Borneo, and Sarawak, as well as Fiji, a part of New Guinea, and many other islands, some held under mandates, and Ceylon further west.

In general it can be said that the Colonies are becoming conscious of their domestic responsibilities and material needs, but unless the natural resources are developed to pay for their needs there is little prospect of raising the masses to play their part in the self-government which is desired. Those who live in those parts of the Empire where applied science has made great economic development possible are inclined to forget the enormous advantages which we, as heirs of work done in the past, enjoy. Great Britain has a social unity more solid than America. Our endeavour is to build up, in all parts of the Empire, a social unity; but we have, for example, in a Colony such as Nigeria, a mass of unrelated tribes. Our greatest Empire problem is the development of the unhealthy tropical countries; we should be encouraged by the amazing prosperity that applied science, British administration, and the creation of the rubber industry by the British brought to Malaya. Malaria was not entirely eliminated there, but its perils had been greatly reduced. The Americans did drive it out of an area of 500 square miles in the Panama Canal zone, but there are more than 500,000 square miles of malarial Africa for us to deal with. Then again, tropical agriculture is a new and very different venture to agriculture in other lands; it was not developed by natives, nor was mineral wealth. Poverty and ill-health affect labour efficiency, but pioneer engineering works, roads, railways, bridges, &c., employ large numbers of natives, so that engineers have to consider health problems.

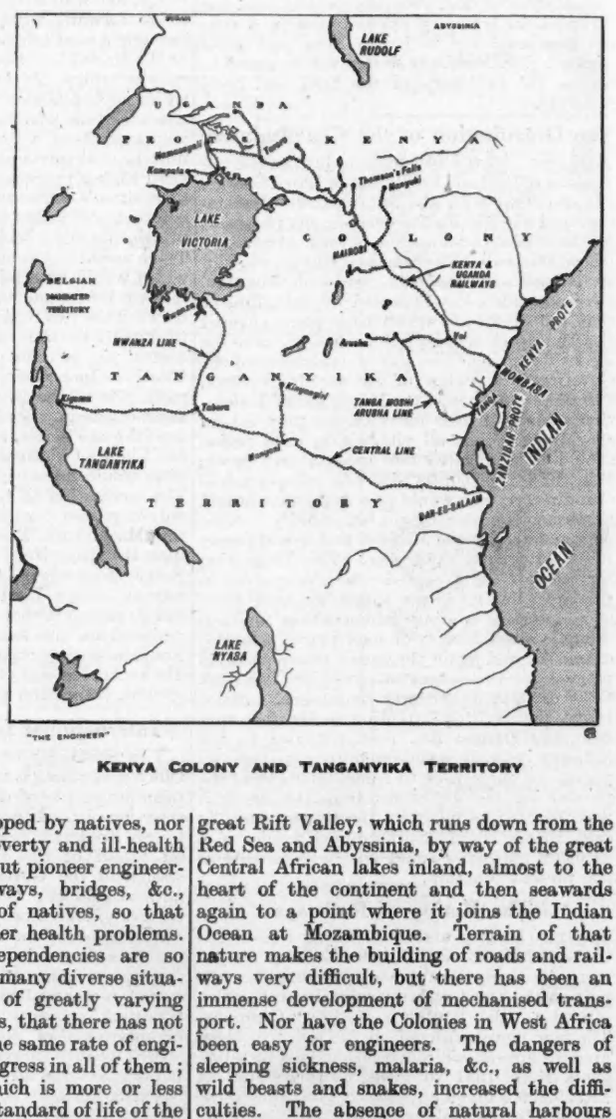
The Colonies and Dependencies are so numerous, and are in so many diverse situations, with inhabitants of greatly varying racial origins and customs, that there has not been, or is likely to be, the same rate of engineering and economic progress in all of them; yet there is a factor which is more or less common. It is that the standard of life of the manual workers is invariably below that which is essential for their physical and mental development. Primitive natives had no wants such as Europeans wished to satisfy, and so labour was indifferent to wages and difficult to obtain. In the new world of rapid communications these people are now brought into contact with modern conditions, such as wireless and international commerce, and have slowly developed a taste for tinned fish, gay cloth, and even bicycles. The contentment of local residents depends on the gradual improvement of their standard of life. Lord Hailey has written: "The primary function of the State (after securing law and order) is the provision of communications and other capital works, and the institution of economic and social services." The foundation of the whole system of economic and social development, nowadays, is the work of engineers. In the tropical Colonies the stage of important industrial development has not yet been reached, although the foundations for mechanised industry have been laid in a few areas.

The African Colonies

The chief geographical features of Central Africa are the varying altitudes, the great chain of central lakes with a number of smaller lakes, particularly in Kenya Colony, and the great Rift Valley, which runs down from the Red Sea and Abyssinia, by way of the great Central African lakes inland, almost to the heart of the continent and then seawards again to a point where it joins the Indian Ocean at Mozambique. Terrain of that nature makes the building of roads and railways very difficult, but there has been an immense development of mechanised transport. Nor have the Colonies in West Africa been easy for engineers. The dangers of sleeping sickness, malaria, &c., as well as wild beasts and snakes, increased the difficulties. The absence of natural harbours made it imperative to spend a great deal of money on construction at ports, such as Takoradi, on the West Coast, and Kilindini, on the East Coast. Messrs. Rendel, Palmer and Tritton designed and supervised the work at Takoradi (1922), estimated at £3,000,000; subsequently additional works were ordered. The trade rapidly increased



MAP OF AFRICOA



KENYA COLONY AND TANGANYIKA TERRITORY

from £3,000,000 to £26,000,000 in 1926.

Some three-fourths of the funds provided by public loans in Africa were spent on railway and port development. At the ports, and then at other centres of commerce, electric supply, pure water, telephones, post offices, and health improvements—especially drainage and reclamations to reduce the danger of tropical diseases—were organised. In places irrigation and water control increase productivity.

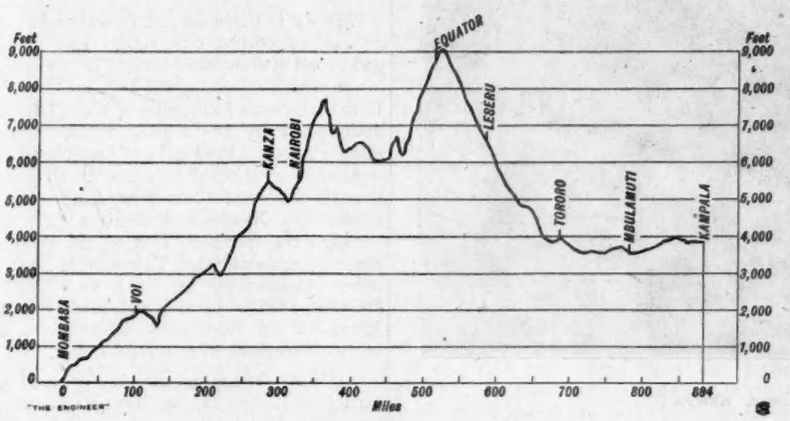
THE RAILWAYS

In general the Empire African railways, outside the Dominion, are single track, with suitable stations for trains to pass. Steel sleepers are often used because of the white ants which destroy timber. The native gangers walk with bare feet and do not disturb the anti-rust covering to any extent; the hob-nailed boots worn elsewhere by gangers cause pitting, &c. Any sleepers in West Africa that are defective are sold to natives for about 7s. each, the original cost to the railway, which makes use of the steel for implements. The sleepers can be produced at a low cost by British manufacturers, at times convenient to them, as they are sure of the demand.

There is one other great reform instituted in recent years by the engineers in the service of the Crown Agents for the Colonies in London. They have standardised road bridges for the Colonies. The designs cover deck bridges of small span for 15ft., 20ft., and 30ft., for the Crown Agents' heavy loading, through bridges of 40ft. span for Crown Agents' heavy loading, and 50ft., 75ft., 100ft., 120ft., 130ft., 150ft., and 200ft. spans for both Crown Agents' light and heavy loading. In the extensive literature prepared by the Crown Agents on this subject tables of diagrams and costs are given in order to assist Colonial engineers in choosing economic spans. Experience has shown that a reduction in both cost and time of delivery is effected by the adoption of standard spans.

The British Government has spent £37 million on East African railways. As far back as 1891 R.E. officers surveyed 2724 miles in Uganda. The Kenya and Uganda State Railway, begun in 1896 and completed in 1901, linked the sea coast with the healthy uplands of the Colony and with the steamer transport on the lakes. The line was not designed as a commercial venture, but to combat the slave trade, which flourished in the regions beyond the reach of the British Navy. It played an indispensable part in the conquest of the neighbouring German Colony. Railways are of metre gauge, which is unfortunate, as it does not coincide with either the Sudan or Union lines, both of which are 3ft. 6in.

The task of building a modern railway in this difficult country was one which demanded the highest engineering skill. At the beginning of the Rift Valley the altitude is about 7400ft.; far along the valley it is just over 6000ft., then it climbs again to over 8300ft. and crosses the Equator over 9000ft. above sea level. In the early days the problem of the drop into the Rift Valley was solved by the simple idea of stopping construction on the edge of the escarpment and starting again on the valley floor. A cableway was provided to handle traffic up and down the mountain side. The object was to enable the railway to progress towards its far objective, Lake Victoria. The engineers were not baffled by the escarpment, but they required time to negotiate the ravines which scarred the side of the hills and the wall of the Rift. A year and a half was saved and the main line was taken 170 miles ahead. Although the line passes over an altitude of 9150ft. and descends again to the level of Lake Victoria, 3726ft., the gradient on the main line does not exceed 2 per cent. The total route mileage of open lines in 1938 was 1265.



PROFILE OF KENYA AND UGANDA RAILWAY

Interior transport in Tanganyika is provided by the railway from the port of Dar-es-Salaam to Kigoma, on Lake Tanganyika, the length being 773 miles. There are various branches to Lake Victoria, &c., totalling about 600 miles. The line is connected with the Kenya and Uganda Railway. There are 334 miles of 3½ft. gauge line in Nyassaland, which has railway connections with the port of Beira and the South African system.

WEST AFRICAN RAILWAYS

Nigeria has a railway system of a total length of 1900 miles. The main line from Lagos inland is 843 miles; there are three branch lines of mileage 275 and a 2½ft. gauge line of 133 miles to the tin mining plateau of Jos, which connects with the main line from Port Harcourt. The line from that port inland joins the western line at 569 miles. A bridge of considerable length crosses the Benue. Thus there are three routes for inland produce to the sea—by rail to the two ports and by river transport on the Niger. The total capital spent on the State Railway system was about £23 million (1936), of which about £20 million was on loan. The rail has lost by competition with road transport in the coastal areas and by ports in the eastern section not served by rail.

There are two railways to Kumasi, in the Gold Coast, one from the new and splendidly designed port of Takoradi (173 miles), the other from the older port of Acra (193 miles). There are five branch lines, with a mileage of 134. In 1936–37 the European staff numbered 101, native clerks 570, and native drivers and semi-skilled employees 1291. Most of the revenue comes from the transport of cocoa, manganese ore, and gold mining activity.

In Sierra Leone the main line runs from Freetown inland 227 miles; a branch line (104 miles) serves the Northern Province. Capital expended was (1936) nearly £1½ million. There is a number of bridges, totalling forty-three, with two spans or more. A company owns a 3½ft. gauge line to connect an iron ore deposit with a port at Pepel. The Imperial Government has spent considerable sums of money on railways in these African Colonies. Much design work was done in London by consultants, and also by engineers in the offices of the Crown Agents.

MAIL TRAIN ON KENYA AND UGANDA RAILWAY

TRANSPORT AND COMMUNICATIONS

"The whole development of the modern Empire has hinged upon mechanical transport." Those words were written by Dr. Knowles, Professor of Economic History in the University of London. They are an unusual—almost an unexpected—tribute

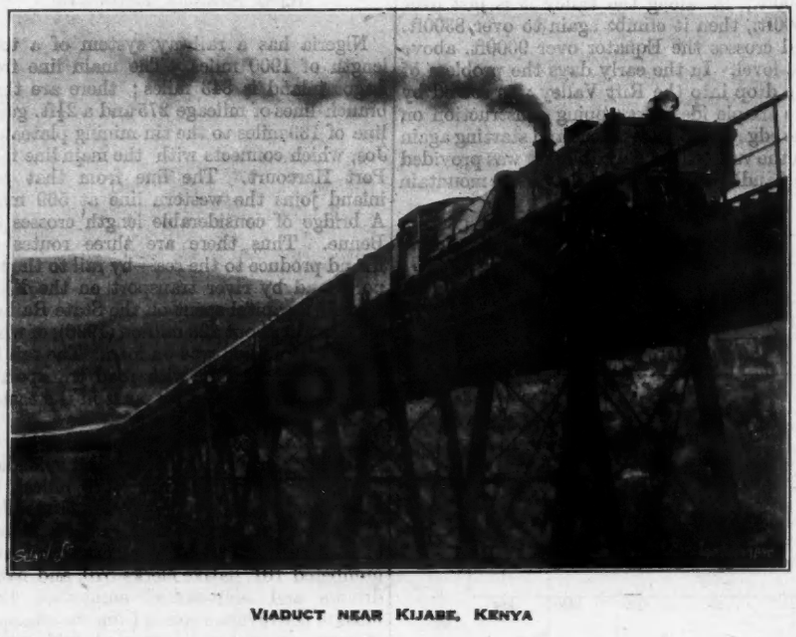
from one, not in our profession, to the activities of British engineers, for their work is but seldom mentioned by those who talk or write about the Empire.

In most regions of tropical Africa the only means of transport was the native porter, for the tsetse made it impossible to use domestic animals, but in Northern Nigeria and the northern parts of the Gold Coast, in the Kalahari and Sudan, either camels, donkeys, or ponies can be used. When the French Government a few years ago purchased 4200 tons of foodstuffs they employed 125,000 porters. An ex-Governor of one of our African Colonies told me that a native carried kernels 200 miles on his head to a market to sell the load for 5s. and walked 200 miles back again. The most urgent need, in many areas, is the substitution of head porterage by mechanised transport.

Water is normally the cheapest form of transport. With the exception of the Nile and Congo rivers systems, internal water transport of any magnitude is confined to the great navigable lakes in the interior, Victoria, Tanganyika, Nyasa Kivu, and Albert. The first steam vessel on any African lake was launched in 1875 on Nyasa; it was carried from the coast in 50-lb. loads by 800 porters. Steamers have since opened up large British and Portuguese areas surrounding the lake, where nowadays crops can be grown for export. Lake Victoria, with a coastline of 4000 miles, from a commercial point of view, is the most important of the great lakes. The Kenya-Uganda Railway operates two 1100-ton steamers and a number of smaller boats and numerous dhows ply between lake ports. Three steamers and a motor launch cover a total route of 830 miles on Lake Albert. Water transport on the lakes has aided the development of cotton, minerals and other exports.

In British West Africa the Gambia alone relies on river transport; it has no railway, but ocean-going steamers can cover 150 miles of the river, and vessels less than 2 fathoms in draught navigate a further 140 miles. Nigeria has about 180 mechanised craft on an extensive network of rivers. Shallow-draught stern-wheelers reach Jebba, 540 miles from the sea. It seems that motor boats will considerably increase the water traffic as time goes on.

The heavy traffic on railways is almost entirely the movement of minerals and vegetable products for export and certain imports. Africa has supplied to the rest of the world large quantities of a variety of minerals. There has been considerable mining activity in the British Colonies and further developments are almost certain.



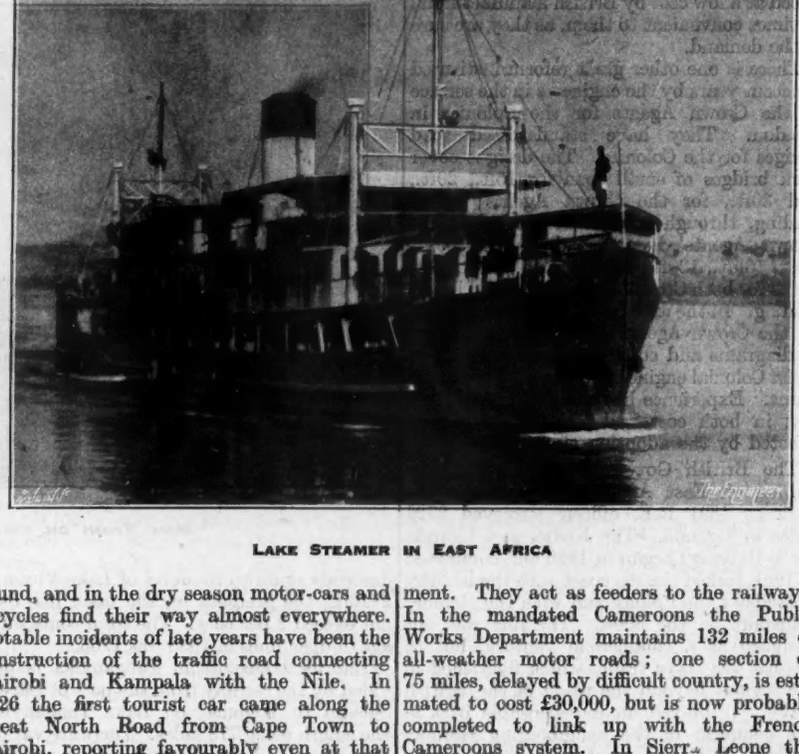
VIADUCT NEAR KIJABE, KENYA

ROADS AND MOTORS

The motor-car has revolutionised transport in Central, West, and East Africa. There are thousands of miles of roads in these territories available for motor traffic all the year round, and in the dry season motor-cars and bicycles find their way almost everywhere. Notable incidents of late years have been the construction of the traffic road connecting Nairobi and Kampala with the Nile. In 1926 the first tourist car came along the Great North Road from Cape Town to Nairobi, reporting favourably even at that date on the 4000 miles of road traversed. About 30,000 miles of made roads are open in East Africa. A number of motor coaches are in use. The total length of the roads in the charge of the Public Works Department in Kenya is now over 10,000 miles, of which 3700 miles are classed as principal arterial roads. In Tanganyika the Public Works Department maintains nearly 3000 miles of main roads and about 1500 miles of district roads, a further 10,000 miles of roads or tracks being maintained by the district administrations from public funds. The railway communications were designed for strategic rather than commercial purposes, and in the large area of the territory more roads are needed.

Uganda is little served by railways; the growth of cotton cultivation has made a good road system essential. The main roads are regarded as among the best in Africa; in 1935 there were 2038 miles of them built and maintained by the Public Works Department. Another 1189 miles of first-class roads, suitable for wheeled vehicles up to 9 tons, were in use, and about 6000 miles of other roads. In Nyassaland a main road runs through the northern part of the territory, connecting with the Tanganyika system; other connections are with the Northern Rhodesia Great East Road, with Southern Rhodesia *viâ* Portuguese East Africa, and with Portuguese to the East Coast.

In West Africa conditions for road construction are less favourable. Road metal is scarce and the climate unfavourable. In Uganda a 24ft. wide road with a 9in. laterite foundation and a centre width of 10ft. installed with granite cost £200 per mile and £30 per annum to maintain. In the Gold Coast a gravelled road for light traffic, 16ft. wide, cost £800 per mile and £50 for annual maintenance. In Nigeria 3775 miles of roads are maintained by the Public Works Department. They act as feeders to the railways. In the mandated Cameroons the Public Works Department maintains 132 miles of all-weather motor roads; one section of 75 miles, delayed by difficult country, is estimated to cost £30,000, but is now probably completed to link up with the French Cameroons system. In Sierra Leone the Public Works Department maintains about



LAKE STEAMER IN EAST AFRICA

800 miles of motor roads: A new motor road, costing £400 per mile, about 80 miles in length, along the coast, has been paid for by the British taxpayer.

AIR ROUTES ACROSS AFRICA

From the modern harbour of Takoradi, in the Gold Coast, to Egypt *vid* Nigeria and the Sudan, the flight of aircraft over the West African reinforcement route for aircraft has been made possible since Italy entered the war in 1940. In 1930 a first flight had been made across Africa from Alexandria through Cairo to Khartoum, on to Kano and Bathurst and back. Imperial Airways had opened a civil air route from West Africa, through Lagos, Kano, to El Obeid, Khartoum, and Egypt in 1936, but the reinforcement route needed greater facilities, and much new work had to be done to construct airfields, &c., over a route of nearly 5000 miles.

When the cargo of aircraft from Britain arrived at Takoradi—six crated Blenheims and six crated Hurricanes—difficulties of transport to the airfield were soon solved by engineers using ingenious devices and a big supply of native labour. Only fifteen days after the first aircraft reached the port the first convoy set off. Soon the staff made a bomber ready for flight within a week of its arrival and a fighter in even a shorter time. And so, over sea, forest, and sand, a regular supply of aircraft, equipment, and men reached the Eighth Army. Some day we shall read of the long hours of work of the ground staff, often out of doors in the humid heat of the Tropics, of the long flights of the air crews over difficult country, and of the reliability of the machines sent out from Britain. In all this work British engineers played a prominent part and so aided the victorious Eighth Army. These airfields will be of great value in the development of commercial aviation in Africa.

The British Dependencies in East Africa form a natural corridor along which aviation routes from North to South Africa must pass. The value of cargo landed and shipped in 1938 by aircraft at Customs aerodromes in these Colonies was nearly £1¾ million.

Lord Swinton, British Minister in West Africa, has told us that at a great palaver of 500 native Emirs and Chiefs in the interior, which he reached by aeroplane, he explained that many minerals were needed for the war effort. Within a few months the natives in the territories—some 27 million in number—built up supplies far exceeding those from areas where industries had been in full swing for years. He told us that West Africa had become a strategic highway for air communications and a vital source of raw materials of all kinds. In Nigeria thirty large airfields had been erected; those made in Gambia were ready a little while before aircraft were ready to cross to Egypt. This African highway also became the route for Russia, India, and China. Over the great chain of airways the British Minister flew in two hours, a journey that would have taken him four and a half days by road and rail, and he insisted that these air communications must be maintained when the war is over. Very large sums of money were spent on these and other engineering developments of permanent value, which would not have been supplied so rapidly in the days of peace.

There are no large electricity supply plants but a number of fairly small stations are in use; with industrial development the demand will increase. Messrs. Balfour Beatty, London, have constructed small hydro-electric plants in the East African Colonies and have also installed some oil engine generating sets.

TIMBER AND FORESTS

It is generally agreed that the greater part of Central Africa was at one time covered by high forest; the surviving belt now occupies only about 8 per cent. of the continent's area. The most obvious cause of deforestation has been native methods of cultivation—involvng burning forests—but there may be other causes, due to Nature. It is only the tropical evergreen forests that are at present able to supply timber to Europe. Those in the Cameroons, Nigeria, and the Gold Coast are most important; those of Kenya and Uganda are smaller in extent. The prevailing type of woodland in the rest of Africa is savannah; an extensive area of hardy trees on soils of low fertility, but to be guarded against erosion.

Forests are important as a valuable commercial asset, but also because of the direct protection they afford to water supply and their influence on climatic conditions, while soil erosion is one of the major and most acute problems facing the Governments and peoples in most of our African Colonies. Burning forests and overstocking areas with cattle often transform into desert land devoid of vegetable cover. The mature top soil is stripped wholesale from the earth's surface; the rain, wind, and the drying action of the sun removes it as silt in rivers or as wind-borne dust. In extreme cases the process is irreversible, but in the earlier stages erosion can be checked.

The Colonial Forestry Service is now well organised. Candidates for it must have a forestry or science degree (with a diploma of forestry) and must take a post-graduate course at the Imperial Forestry Institute, the final year of which is completed after a tour of service in Africa.

THE INDUSTRIAL REVOLUTION IN AFRICA

In African Colonies many of the inhabitants are farmers, growing cocoa or palm nuts, maize, cotton, natives often living in villages far away from a main road. The transition from an economic stage where exchange of commodities was by barter to the use of money; the replacement by regular taxation of sudden bursts of extortion; the freedom from a state of slavery to payment for labour—all these new ideas, impinging on primitive peoples, as in Africa and the West Indies, made alien rulers tread delicately. Engineers found many difficulties due to old superstitions and religious rites.

In 1924 a school and college at Achimota, near Accra, was opened. Every boy and girl at Achimota, from the start, did manual work. To-day, African students in engineering there can win the London degree; one old student is in charge of a sub-hydro-electric station in Nigeria. Recently the British Government made a grant of £127,000 to finance at Achimota a research institute to aid industrial development. It will make a survey of West Africa to see what industries can be established and where; this will be accomplished by experts in different trades, a business expert, an economist, and a sociologist. African chiefs are sending their sons as apprentices and backing the experiment; so are the Government, missions, and trading firms. There will be trial factories in various places and proper standards of wages and housing.

(To be continued)

The Electron Microscope and its Application to Engineering Problems

By A. G. QUARRELL

No. I

THE maximum magnification which may usefully be employed in any microscope is determined by the resolving power of the system, and this in turn is governed by the wavelength of the radiation used to illuminate the specimen. When ordinary light is used, particles smaller than about $0{\cdot}2 \times 10^{-3}$ mm. cannot be identified as such, and even with the ultra-violet microscope the limit of resolution is of the order of $0{\cdot}15 \times 10^{-3}$ mm. For this reason the maximum useful magnification attainable is some 3000 diameters, and no enlargement of the image beyond this point can increase the amount of detail visible in the picture. For a number of years it seemed that the practical limit of resolution had been reached, and that little further progress could be expected, but the discovery in 1928 that high-speed electrons could be diffracted opened up new possibilities. G. P. Thomson's experiments confirmed that a wave system must be associated with moving electrons, and supported de Broglie's earlier contention, based on theoretical considerations, that the electron wavelengths were some 10^4 to 10^5 times shorter than those of visible light. Provided suitable lenses could be obtained, therefore, much higher resolving powers and much greater useful magnifications should be possible with the electron waves. Indeed, the theoretical resolving power associated with electrons which have been accelerated through some 50 kV to 80 kV is such that it should be possible to distinguish individual atoms in a specimen.

The pioneer work on the high-resolution electron microscope was carried out by Knoll and Ruska[1] in 1932. For many years they had been working on high-speed cathode ray oscillography, and this had an important influence upon the design of their electron microscope. Any axially symmetrical arrangement of electric or magnetic fields will act as a lens upon an electron beam, but experience in oscillography had shown the magnetic lens to be more convenient for high-speed electrons. In view of this, Knoll and Ruska used a combination of magnetic lenses in their first electron microscope—a feature which has been adopted in most of the high-resolution instruments since developed.

The fact that the magnetic field of a solenoid would act as a lens and enable electron images to be produced was known some time before the wave nature of electrons was realised, and in 1926 Busch[2] dealt fully with the theoretical and practical aspects of the image-forming properties of the magnetic lens. He developed a formula for the focal length and also confirmed it by experiment.

According to him, the focal length f of the magnetic lens is given by

$$f = 48 \cdot 4 \, V \left(\frac{d \, F}{I \, N} \right)^2 \text{ cm.}$$

where V is the potential in kilovolts through which the electrons have been accelerated, d is the mean diameter and N the number of turns on the coil, whilst I is the current passing through it and F the coil factor. The exact value of the coil factor must be determined experimentally, but for rough estimates of the number of ampere turns required it may be taken as unity.

It will be seen that the focal length of the magnetic lens is controlled by the current which flows through the winding and can therefore be varied within a considerable range. The minimum value of the focal length, which should be as small as possible if large magnifications are to be obtained, is determined by the geometry of the coil, and

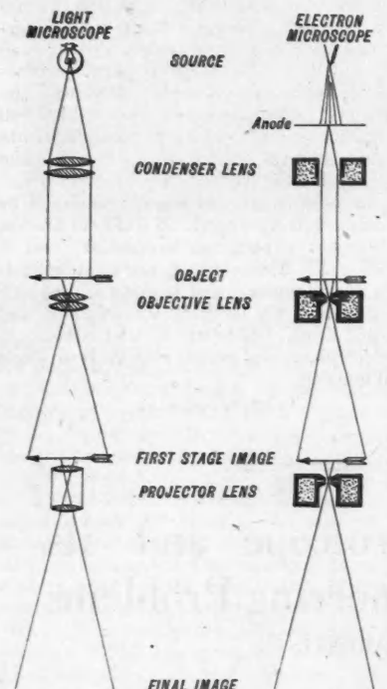


FIG. 1—COMPARISON OF LIGHT AND ELECTRON MICROSCOPES

as a general rule it may be assumed that if the coil is shrouded with iron the minimum focal length will be one-third to one-quarter of the inside diameter of the iron shield. It follows from Busch's formula that if the focal length of the lens is to remain constant, so that sharp images can be obtained, it is necessary that the D.C. supply to the coils shall be such that current fluctuations are reduced to a minimum, and the potential through which the electrons are accelerated must likewise be accurately controlled.

The image-forming properties of the magnetic lens are almost identical with those of a bi-convex glass lens, except that the image is not inverted, but rotated through an angle which depends upon the object and image distances. As indicated in Fig. 1, the electron microscope includes the same essential features as the optical microscope, but with magnetic lenses replacing glass ones. An electron beam is generated in a hot cathode tube run at 40 kV to 80 kV, and in order to give uniform illumination of the object the beam is rendered parallel by means of a magnetic condenser lens. It is usual for this lens to be enclosed in an iron shield, but without specially shaped pole pieces. Owing to the small penetrating power of even high-speed electrons, the object must be in the form of a thin film not more than about 10^{-4} cm. to 10^{-5} cm. thick, and is placed just above the magnetic objective. This lens gives a magnification of about $\times 100$ in the first-stage image, of which a small central area is further magnified by the magnetic projector lens to give a final image at a magnification of 15,000 to 25,000 diameters. The electron microscope is focused by adjusting the objective current, but the magnification is varied by changing the current passing through the projector coils.

In modern instruments both objective and projector coils are encased in iron and fitted with specially designed pole pieces. Pole pieces were first used by Ruska in 1934 with the object of keeping the physical size of the coil itself sufficiently large to prevent overheating of the winding, whilst the magnetic field was concentrated into a very small zone by the accurately machined pole pieces. The correct shaping of the pole pieces has an important influence upon the quality of the image, and the internal diameter must be small if the very short focal lengths necessary for high magnifications are to be obtained.

A modern commercial electron microscope manufactured by the Radio Corporation, of America, and described by Zworykin[3] is illustrated in Fig. 2, and typical electron micrographs taken on it are reproduced in Figs. 3 and 4. Zworykin states that no fewer than fifty of these electron microscopes are in operation in various institutions in the United States. As will be seen from Fig. 2, the equipment is extremely compact, the cabinet to the rear of the microscope accommodating all auxiliary electric circuits, including the high-tension generator and the electronic voltage regulator used to supply the magnetic lenses.

As far as the microscope itself is concerned, unit construction is adopted throughout, the electron tube unit, condenser coil, object chamber unit, and so on being joined together by plane ground surfaces which are sealed with low vapour pressure grease to give vacuum-tight joints. By using adjustment screws provided between adjacent sections of the microscope it is possible to ensure that the electron beam issuing from the hot cathode tube is in perfect alignment with the axes of the magnetic lenses. Owing to the small apertures of the pole pieces each section of the microscope must be evacuated separately, and the main vacuum pipe line can be seen slightly to the rear of the main microscope tube in Fig. 2. The flexibility necessary to enable vacuum-tight joints to be maintained whilst the different units are adjusted is obtained by means of metallic bellows incorporated in the vacuum line.

A fluorescent screen may be turned into the beam just above the projector coil and the first stage image observed through an observation port in the side of the microscope. Similarly, the final image may be observed on a fluorescent screen mounted on the shutter used for exposing the photographic plate placed below it. Both object chamber and camera are fitted with air locks so that specimens and photographic plates can be changed without admitting air to the microscope column.

The object, which must be capable of withstanding a high vacuum, is usually in the form of a thin film or a suspension supported on a thin structureless film, and is mounted on a disc of fine-mesh wire gauze. This disc is inserted into a small cartridge and introduced into the object chamber. The manipulation of the air lock mechanism to bring the specimen into place above the object lens is so simple that changing the specimen interrupts observation for only about one minute.

With an operating voltage of 60 kV the exposure times range from one to ten seconds and the electron-optical magnification of the pictures on the photographic plate can be varied from 1000 to 30,000 diameters, the low magnifications proving particularly valuable for direct comparison with light micrographs of the same specimen. The resolution is so good—3×10^{-7} cm. or better—that most pictures contain enough sharp detail to justify further photographic enlargement, resulting in useful magnifications of 50,000 to 100,000 diameters. Some idea of this resolution can be gained from the fact

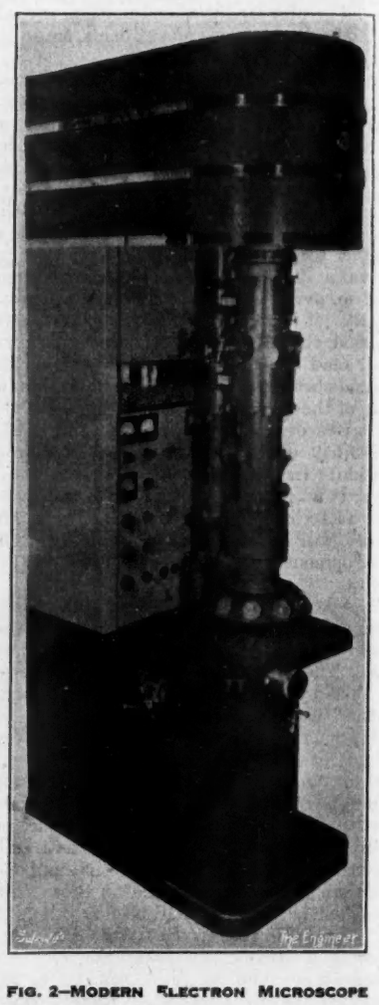


FIG. 2—MODERN ELECTRON MICROSCOPE

that a filament of iron twenty atoms thick would be clearly resolved.

The depth of focus obtainable with the electron microscope is considerable. Spherical aberration occurs with magnetic lenses as with simple glass lenses, and in order to minimise the effects of such aberration the angle of illumination at the object is reduced to about one-sixth of a degree. It has been calculated that this leads to a depth of focus of some 2×10^{-4} cm., whilst the maximum specimen thickness compatible with really high resolution is about 5×10^{-6} cm. It is clear, therefore, that every part of the specimen can be readily focused and the production of the photographs such as that of zinc oxide smoke shown in Fig. 3 is quite understandable.

Some of the most spectacular results have been obtained by applying the electron

microscope to a study of biological specimens too fine for detection in the light microscope, but interesting results have also been obtained in the chemical field. In particular, the new technique has proved useful for determining the characteristic shapes and the size distribution in finely divided matter. These factors are of considerable importance in the case of many reagents, catalysts, and so on, and it would seem that important results may be expected in this direction. The starlike particles characteristic of zinc oxide smoke are shown in Fig. 3, which is due to Zworykin. At a magnification of

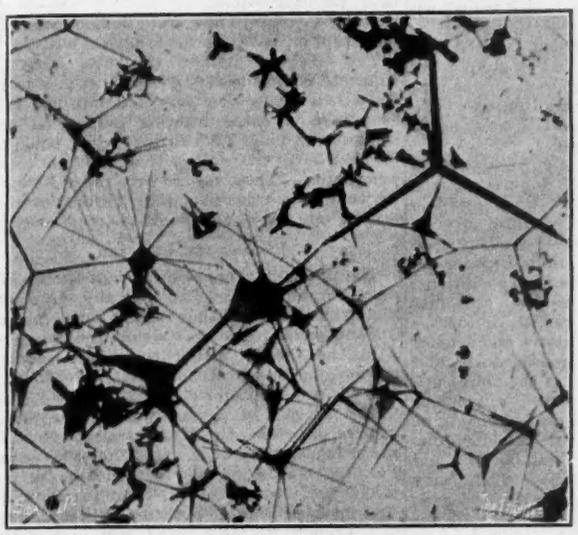


FIG. 3—ELECTRON MICROGRAPH OF ZINC OXIDE SMOKE

50,000 diameters magnesium oxide smoke shows a mass of small cubic crystals with a few larger ones. Tungsten oxide smoke gives a less well-defined pattern, but it is in keeping with the tetragonal structure of the dioxide. Aluminium oxide smoke is interesting because at 30,000 diameters all the particles appear to be perfect spheres.

Hall and Schoen[6] have applied the electron microscope to a study of photographic materials. Hall was associated with Professor Burton in the early days of development of the electron microscope at Toronto University, and the instrument used by Hall and Schoen at the Kodak research laboratory was essentially a copy of that at Toronto. Supports for the specimen were made from a dilute solution of cellulose nitrate in amyl acetate. A drop of the solution was allowed to spread over the surface of a tray of water, and after the amyl acetate had evaporated a thin film of cellulose nitrate remained. This film was picked up over a fine-meshed wire gauze and used as a support for the photographic emulsion. Cellulose nitrate films prepared in this manner appear to be structureless in the electron microscope and are sufficiently thin to enable the highest resolving powers to be attained.

When silver halide crystals were first exposed to the electron beam in the electron microscope they appeared opaque, but on further exposure they began to show transparent holes and cracks due to migration of silver ions within the halide lattice (Fig. 5). At the same time a halo was gradually formed about each crystal, and examination after the crystals had been fixed in the normal manner showed that the haloes persisted and therefore must be at least partly silver and presumably caused by migration of silver to the surface of the lattice. It did not prove possible to detect latent image particles produced by normal exposure, but very small silver particles were detected within silver bromide crystals after exposure to an intense light source. Examination with the light microscope had resulted in a generally accepted view that developed silver possessed a "cokelike" structure, but the electron microscope showed that the developed silver consisted of interwoven filaments. In fully developed grains the filaments were so closely packed that the grain was opaque to electrons, except near the edges where the filamentary structure was clear. It was found that occasional filaments extended far beyond the original crystal boundaries, so that they might penetrate neighbouring crystals and render them capable of development. All the usual chemical developers produced this type of structure, but whereas metol and amidol produced very fine filaments, hydroquinone yielded coarse ones. By way of contrast, "physical development," which gives a fine-grained image, was found to produce clumps of closely packed silver particles.

The smallest photographic crystals at present available are those in Lippmann emulsions, and Hall and Schoen found that after development in any of the usual chemical developers each small crystal grew into a single filament, which was much longer and thinner than the original crystal.

The importance of results such as these in leading to a better understanding of photographic processes cannot be over-emphasised, and it is reasonable to expect that further application of the electron microscope to such problems will yield handsome dividends.

Until as recently as 1940 it appeared that the high-resolution electron microscope could be applied to metals and alloys only when they were in the form of thin films or fine particles capable of forming a suitable specimen on a cellulose support. In that year, however, Mahl[5] suggested that thin replicas of metal surfaces might be prepared and examined directly in the electron microscope. He anodically oxidised an aluminium surface and dissolved the underlying metal in saturated mercuric chloride solution. In the resulting electron micrograph level portions of the original surface appeared light, whilst steeply sloping elements appeared dark owing to the greater thickness of the replica effective in absorbing the electrons, and the effect was not unlike that of a light micrograph taken with oblique illumination. This method of replica formation is not of general application, although it has been suggested that an aluminium film be deposited on the etched surface of the metal to be examined, oxidised, and the aluminium oxide film stripped for use in the microscope.

A number of other methods of replica formation have since been developed, and the first stage in the method favoured by Zworykin consists in depositing a fairly thick layer of silver on to the etched surface by evaporation in vacuum. After stripping from the specimen, this thick silver film carries an exact imprint of the etched surface, and a drop of collodion solution is allowed to spread over it. Surface tension causes the upper surface of the collodion to become plane, whilst the lower conforms to the imprint made in the silver by the original specimen. There are thus variations in thickness of the collodion in keeping with the depth of etching of the corresponding portion of the metal specimen. After the silver has been dissolved away by immersion in dilute nitric acid, the collodion film constitutes a positive replica of the original surface and, after washing and drying, may be examined in the electron microscope in the usual manner. One of the earliest and most striking electron micrographs produced by this method is that of pearlite, shown in Fig. 4.

If the collodion is given inadequate treatment in nitric acid, black spots, due to undissolved silver, appear in the resulting micrograph, but the effect is generally easy to detect. The use of silver is eliminated in what is known as the Formvar process. If the collodion film be formed directly on the metal surface and stripped mechanically the results obtained are relatively imperfect owing to distortion of the film in stripping, but Schaefer and Harker[4] have found that excellent results can be obtained if the

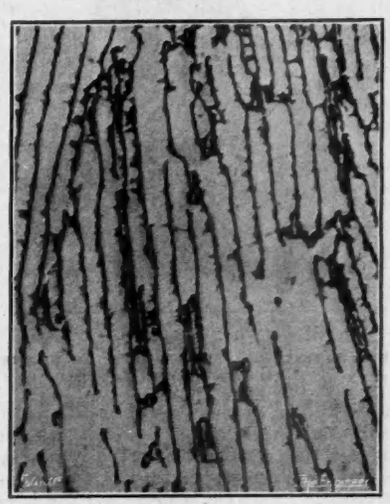


FIG. 4—ELECTRON MICROGRAPH OF PEARLITE

collodion is replaced by a solution of polyvinal formal, or "formvar" in dioxane. The formvar solution is placed on the metal surface immediately after etching, and after evaporation of the solvent the negative replica can be stripped from the specimen under water. Distortion of the replica during stripping can be minimised by forming a gelatine film on top of the formvar and subsequently freezing it. Differential contraction causes the gelatine with the replica attached to separate from the metal surface. After removal of the gelatine by washing in water the replica is ready for use. By contrast with the silver-collodion method the formvar process yields negative replicas.

Another method of obtaining positive replicas is the polystyrene-silica method developed by Heidenreich and Peck[7] and used with considerable success in the examination of light alloys. A polystyrene moulding of the etched specimen is made at 70 deg. Cent. and 2000 lb. to 5000 lb. per square inch pressure. After cooling, surplus polystyrene is removed and the specimen either lifted out of the impression which it has made or, if necessary, dissolved in a suitable reagent. The polystyrene surface carrying an imprint of the etched metal is now coated with silica

by evaporation in vacuum from a tungsten spiral containing a few quartz splinters. When sufficient silica has been deposited the polystyrene is dissolved in ethyl bromide and the silica film is employed as a positive replica.

The results so far obtained by application of the replica method to metals and alloys leave no room for doubt that an extremely valuable method of attack has become available. It was natural that metallographers should at first view the new method with a certain amount of reserve, particularly in view of the intermediate stages introduced after etching the surface. The complete agreement between electron micrographs at relatively low magnifications of 1000 to 3000 diameters and high-quality light micrographs, together with the obvious excellence of the pictures obtained at extremely high magnifications, has done much to break down this reserve. In a study of the structure and rate of formation of pearlite, Mehl[6] prepared specimens for examination by Zworykin and his colleagues, and the electron micrograph shown in Fig. 4 is an excellent example of the results obtained using the silver-collodion

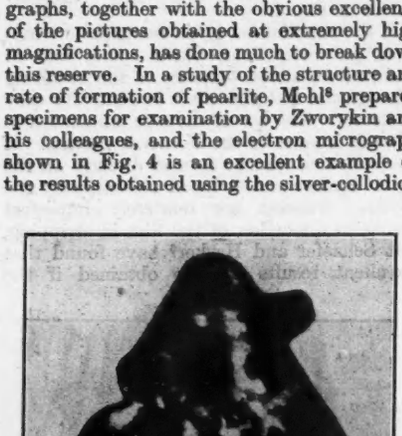


FIG. 5—ELECTRON MICROGRAPH OF SILVER HALIDE CRYSTAL

method. The specimen had been allowed to transform isothermally at 640 deg. Cent. and the structure could not be properly resolved in the light microscope. As the temperature of pearlite formation is decreased the interlamellar spacing decreases steadily until a structure is obtained which the ordinary metallographic microscope cannot resolve at all. Whilst many metallographers have subscribed to the view that this structure, generally known as nodular troostite, is in fact very fine pearlite, others have disagreed strongly and it is therefore of considerable interest that Mehl and Zworykin have been able to show that there are no areas in such nodular troostite which cannot be resolved into lamellar pearlite. The interlamellar spacing in this very fine pearlite was shown to be as small as 3×10^{-6} cm., and it is not surprising, therefore, that it cannot be resolved in the light microscope.

Mehl also gave electron micrographs in which the fine structure of the intermediate product "bainite" was resolved, although there was no clear registration of carbide particles at 18,500 diameters.

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(To be continued)

Engineering in Early Warfare*

By R. P. HOWGRAVE-GRAHAM, F.S.A.

SIEGE warfare as opposed to open battle has always involved the opposition of inventive and engineering intellects; except in the design of guns and bridges, it is principally in modern times that machinery has become a vital feature of war in the field. Underground attack, often the most successful, has always been prominent in siege warfare, and while flat trajectory projectiles were in use, the high walls, towers, and keeps afforded magnificent passive defence if only their approaches and foundations could defy the miner, and their thickness and soundness the terebra, the ram, and the stone ball.

The introduction of the high-trajectory trebuchet—the howitzer of the Middle Ages—was a likely cause of increasing heights, but with the hard iron ball propelled by gunpowder came reduced height, increased horizontal thickness, and more earthworks. Hence we have the squat castles of Henry VIII's time, as at Walmer, Camber, and Sandgate.

The culmination, due largely to howitzers, mortars, and bombs, was in the dug-out systems of the Great War of 1914–18, when a whole great country was in an almost static state of siege. One wonders what would have happened if a full-length Maginot Line, fully dividing the Continent, had been held under ideal conditions.

"Engineers" in siege warfare are first definitely mentioned in the twelfth century.

Various available means of attack and defence were, of course, often used simultaneously, and it is interesting to note that in the thirteenth century, which saw an almost miraculous development of the arts and a new stirring of the scientific spirit, the castle builders discovered that offence is the best defence and developed revolutionary designs which came near to making the besieged men the besiegers, as in the great city of Carcassonne. All the devices reviewed in detail below will be fully illustrated from documents and pictures.

(1) *Blockade.*—Investiture and starvation were used, and though in one three-year blockade by William the Conqueror an opposition castella was placed on his lines of communication, this hardly belongs to engineering.

(2) *Escalade.*—The frequent use of scaling ladders demanding extraordinary persistence and courage is astonishing when one considers the advantage of the defender above, often protected in the hoardings or machicolations and with the force of gravity on his side. Interesting drawings of scaling ladders and grapples survive. Such devices merely brought the fighting men to grips with the enemy with the hope of entering the fortress in sufficient numbers to gain control of the gates and let in the besiegers. Mounds of rubbish, if built high enough, served the same purpose or supplemented the ladder.

(3) *Means of Approach.*—Escalade involved reaching the foot of the wall; devices for doing this in safety are dealt with subsequently.

(4) *Fire.*—Fire was applied to gates by the use of faggot bundles and in one case of numerous carts full of dry greased wood. There was also the terrible Greek fire, which was sometimes hurled by projectile engines. There were fire-pots thrown by hand and machinery and flammenwerfer projecting fire from copper tubes.

(5) *The Mine.*—The usual method was to mine beneath a tower or curtain wall, propping the tarred and greased timber as in a coal mine, and then to fire the chamber and retire. The enemy countermined and there were terrible underground battles. Many stirring accounts of such operations are given. Sometimes the mining was at the foot of the wall under protecting structures placed by the besiegers. Explosive mines were used at the siege of Naples in 1503, perhaps for the first time.

(6) *The Battering Ram, Tanks (Animate and Inanimate).*—Of these, examples are shown from Assyrian times to the fifteenth century. They were often used under cover and ranged from a crude piece of tree trunk, with which men ran at a gate, to immense iron-shod timbers swinging on chains under long tunnel-like protective sheds. The defenders lowered cushioning objects or else grappled or tangled the swinging ram with ropes and chains. Some rams were on wheels; beak-rams were common on ships many hundreds of years B.C.

The Bore or Terebra.—This was a heavy timber with a sharp iron head of square section; it was crashed into mortar joints and then rotated; it was lighter, more portable, and easier to work than the ram.

The Shelter for the Ram and Terebra.—For this kind of attack and for simple work with picks there were tunnel-like shelters with strong roofs often covered with wetted raw hides against fire. Some were enormous structures on wheels with the ram or bore inside and they had many amusing names.

Fixed Towers.—These were built outside the fortress or on a ship—a castle against a castle.

The "Belfry," "Gate," or "Cat Castle."—Immense rolling towers were sometimes used. They had stages for protected bowmen and sometimes a stone-throwing engine on the summit or a hinged drawbridge which could be lowered on to the wall so that besiegers could pour across. These towers were rolled forward by windlass or other machinery inside, but were exceedingly heavy and liable to topple over.

PROJECTILE ENGINES

The projectile engines of ancient times were more formidable than is generally supposed, and it has been said that further developments might even have delayed the coming of gunnery.

In the Classic period there are frequent references; Philip of Macedon, 382–336 B.C., and his son, Alexander the Great, used them freely. Stones of ½ cwt. were thrown 400 to 500 yards. The Greek Agistratus gives the range as 3¾–4 stades, *i.e.*, 700–800 yards. Plutarch speaks of the incredible noise and velocity of stones thrown from machines by Archimedes (Siege of Syracuse, 214–212 B.C.), and though Plutarch lived two and a half centuries subsequent to the event, he can scarcely have invented the noise of the engine stone. Many writers speak of the terrifying noise of stones which, if slightly tinted, were invisible in flight. The propellant energy came from immense skeins of twisted sinew; in one siege insufficient material led to the women in a city giving their hair. The engines of the Middle Ages are often, as previously explained, difficult to interpret, not only because of the illustrator's ignorance, but often doubtless because mechanism did not interest him.

The multiplicity of names given to these engines leads to confusion. I have attempted to divide them into classes, but there is overlap, and my classes are tentative; the distinctive names are given with the classes. The following are general terms:—Engine, Gyn, Fundus, Fundibula.

There are also pet names for individual machines, and these are sometimes used as if they were rather names of a type. We have War-Wolf, Sow, Wild Cat, Mutton, La Perriere, bad neighbour, and Malvoisin (bad kinsman). With these may be compared gun names such as Granny, Long Tom, Big Bertha, and (earlier) De Dulle Griete at Bruges, and Mons Meg at Edinburgh. Type names of guns and shells are Archy, Jack Johnson, and whizz-bang.

Classes and Names.—(*a*) *The Catapult* (Kata = away + pallein = hurl): Catapulta, Torimentum, Catabula, Cabula (Philip le Bel at Chateau Gaillard), Mango, Mangon as early as A.D. 886, and its diminutive Mangonel, Onager, and Nag (twelfth-century Norman soldiers). The last two names refer to the recoil which made them kick up at the rear. Onager = a wild ass. (*b*) *The Ballista:* Ballista, Ballistarium, Balistade de Turno (because of the winches used), Carro-Ballista (Ballista on wheels). (*c*) *The Springal:* Springal, Spurgardon (?) (the word springal still used by poachers for traps worked by a bent twig). In the Middle Ages it was a term for a sprightly, active youngster. (*d*) *The Arbalest* (arcus = bow + ballista = military engine): Arblast, arcuballista, arbaleste. (Larbalestier is still a surname. I remember a family of that name in Southampton.) (*e*) *The Trebuchet:* Trebuchet, Trebucet, Trebucket, Tripanta, and Biffa (!).

* Newcomen Society, London, November 10th.

(*a*) *The Catapult.*—Everyone knows the skip-jack action of the siege catapult with its tremendous twisted skein of sinew, hair, or cord and its cup-shaped head for the stone ball. The windlass used for winding it up seems to have had a ratchet and pawl and release was by a trigger. The arm moved through an arc of approximately 90 deg. and was arrested when nearly vertical by a leather cushion pad on a heavy cross beam. The arm was made of multiple spars of tough wood bound tightly with wet raw hide, which shrunk and set like iron. Slackening of the skein was taken up by rotating its attachment at one end and by means of levers thrust into holes as in a capstan head; a ratchet and pawl prevented return. Doubtless these details were widely varied.

It has been stated that strength and flexibility were lost after the conquest of Greece, 146 B.C., and modern experimenters, having failed to recover the secrets, have found deterioration rapid and moisture a great enemy. Sir Ralph Payne Gallwey has built experimental engines having a range of 300 to 400 yards. One was 13ft. long and weighed 2 tons, but was still only half the size of many ancient engines.

(*b*) *The Ballista.*—This had two arms, operated by skeins on either side. The skeins were vertical, so that the arms rotated about a vertical axis. When not set for action the arms projected outwards nearly at right angles to the line of fire and their tips were connected by a heavy cord which was then straight and tensed. A grapple drew back the cord as in a crossbow and in one form a block which carried the grapple slid back along a central beam provided with a ratchet and had a click so that the extension could be varied. When set, the cord, drawn like a bow string, pulled the arm tips inwards towards the central beam, thus increasing the skein torque. In front of the sliding block was placed a large arrow or javelin in a longitudinal groove in the central beam. A windlass drew back the block and release was secured by a lever which freed the cord from the grapple. Obviously the aim, and especially the trajectory of this weapon, is immensely superior to that of the cup catapult, and it would seem to have advantages over the catapult as adapted for javelin throwing. Its missiles were stone balls, darts, great arrows, and the "falarica"—a long javelin-headed pole.

The Romans had a regular field artillery of mule-drawn "carro-ballistae," or wheeled machines. Each cohort (about 500 men) had one catapult, according to one record, but Vegetius, a late Classic writer, speaks of 60 carro-ballistae per legion, one carro-ballista being worked by 11 men. (A legion is about 5000 men.) Livy ("Conquest of Carthage," 146 B.C.) says: "There were taken from the defenders 153 great and 252 small catapults and ballistae." Richard I and Philip II at the Siege of Acre (1191) had 300 ballistae and catapults.

(*c*) *The Springal.*—Viollet le Duc says that this type was introduced in the thirteenth century. A central vertical post was slotted to allow the passage of a javelin, the rear end of which projected backwards. A multiple spring-beam held to the base of the post was pulled back by a geared winch, exactly as the facetious, but ill-mannered, diner pulls back a table-knife blade to project a bread pill across the table. When released it struck the javelin, which slid in a guide or groove. The vertical post rotated about its axis with the tail beams in bearings, in the same way as did the earliest post mills, so that the springal could be aimed. Da Vinci (1445–1520) shows a springal used for throwing one ball from a cup and another from a sling. As drawn, the cup would release its ball at the wrong moment. The action of the sling is described under the Trebuchet.

(*d*) *The Arbalest or Arblast.*—This was originally a large engine and apparently was invented or re-invented as a small arm in the eleventh century as the cross-bow. In this form the bow was of thick finely tempered steel, and was far too stiff to be drawn by hand. Various mechanisms were devised for drawing, the commonest shown in illuminations being worked by a pair of crank handles, 180 deg. apart. The front end of the cross-bow had a stirrup into which the soldier put his foot, and so held it down to the ground while winding.

An interesting machine for the same purpose, but detachable, was the Moulinet or Crannequin. [An example was shown. It is a fine piece of ironwork in which one lantern pinion has only three bars. The multiplication from handle to the drawing claw is 100.]

Cross-bow bolts were short, thick, and heavy, and sometimes had wooden wings with a high-pitched rake on them to make the shaft spin. [Specimens from the Ruthaus at Cologne, with rather gruesome forms of head, were shown.]

Large-scale arblasts were used by Belisarius, the great Byzantine defender of Rome, in 537. Leonardo da Vinci in "Il Codice Atlantico," shows a huge arblast drawn by a long screw, which is turned by a cog wheel engaging with a worm operated by several radial spokes. The drawing suggests that setting the cord must have been an impracticably long process. There are at least eighty threads to the screw and the cog wheel has about thirty-two teeth. It would seem that about 2560 revolutions would be necessary. The multiple spokes are evidently not designed to revolve once with one movement of the winder's arm, but even if he achieved a whole revolution per second it would take about forty minutes to set.

Viollet le Duc illustrates a combination catapult and arblast with a stone cup; but I have an idea that this is a flight of his own fancy.

The famous MS. of Walter de Milemete (1326–27) has a delightful picture of an arblast loaded with a great arrow and drawn by a screw. Here the false perspective is helpful. This manuscript contains many engines of fanciful and even ridiculous type, and also the first authentic drawing of a gun. It shows a queer vase-shaped bombard charged with a javelin.

Before leaving the flat trajectory types, one may mention a case of a man being transfixed to a tree and that of the alleged piercing of several Danes by one javelin during the Siege of Paris in the ninth century. Abbot Ebolus, with grim humour, called to their friends to take them, ready spitted, to the kitchen.

(*e*) *The Trebuchet.*—This terrible but simple device was by far the commonest projectile engine in the Middle Ages. It was the howitzer of those times, and large ones cast immense stones and other projectiles at much lower velocity than was given by the flat-trajectory catapults and other types, but the angle of departure was very high, and the stones hit high walls or soared over them and dropped into the fortress. I think that wherever we find records of very large projectiles, we can assume that a trebuchet was used. Most of the thrilling and dramatic accounts published may be assumed to refer to trebuchets, though the word very rarely occurs. My earliest contemporary account is of the date A.D. 1190.

The French architect Viollet le Duc gives a splendidly drawn reconstruction of a large trebuchet. This and one built by Sir R. P. Gallwey are among the many mediæval drawings and illuminations shown.

A great beam, sometimes a tall tree, turned about trunnions near its thick end, which carried a huge counterpoise often hinged and commonly made by filling a bin or box with earth or stones. The beam was called the verge (*cf.* verge in a clock and verger in a church). Before setting, the verge was vertical. When pulled over through nearly 90 deg. by means of capstans, it was secured by pegs or straps allowing easy release. At the thin end was a slightly bent hook, the concavity of which faced towards the target, and to this end also was fixed one extremity of a long sling made of rope net, the other extremity having a ring or eye which was passed over the hook. The sling was expanded at the bottom, where it hung as a loop, and in it was placed a stone ball, unless special projectiles were used. The whole was supported by a timber structure, which was often of vast size, and at ground level there was a long smooth trough. When the verge was pulled over to the horizontal, with its head at the rear, the projectile in its sling was laid at the front end of the trough and was often further forward than the bearings of the verge. On release, the upward movement of the verge head dragged the projectile backwards with high acceleration, so that it flew outwards and upwards, keeping the sling under tension until somewhere near the moment of highest angular verge velocity the projectile was moving at a radius nearly equal to the verge length plus the sling length. At a moment fixed by the curvature of the hook, the eye slipped off and the projectile left the sling. The trebuchet always had a sling, and it must have been an impressive sight when an engine about 45ft. high hurled a stone ball 18in. diameter, after whirling it in a 90 deg. arc in its sling.

Egidio Colonna in "De Regimine Principium," mentions four varieties:—

(1) With fixed counterpoise.
(2) The "Biffa" with movable counterpoise for range adjustment.
(3) With fixed counterpoise and intermediate sliding weight.
(4) With no counterpoise, but with stretched ropes.

No. (4) may mean ropes in large clusters worked by many men, for such appear in manuscripts. The maximum range was probably about 300 yards. Masses were often about 2 cwt. to 3 cwt. One writer mentions 12 cwt., and King John at the Siege of Bedford had seven engines at work together, and threw millstones. At Kenilworth there are masses of trebuchet balls, and one is 18½in. diameter. Numbers at Pevensey weigh 144 lb. to 241 lb. Other missiles were logs of wood and clay balls baked with heavy pebbles. These broke up and so could not be returned. A terrible missile was a barrel of Greek fire, but arblasts could only throw incendiary arrows. First-hand accounts of the hurling of great stones and fire barrels are extraordinarily realistic, but are too long to be quoted here. Casks of dung were thrown into cities in order to spread fever and in one case it is stated that this end was attained by the use of 2000 cartloads. Dead horses were cast for the same purpose, and Da Vinci gives a drawing illustrating this. Another terrible projectile was the living body of a spy, and one writer gives directions for trussing up a man to form a round bundle like a sack of grain.

It is pleasanter to dwell upon the use of trebuchets for showering masses of roses on the ladies in the tournaments of love. [This was illustrated by the carving on an ivory casket.] It is pleasant, too, to read Froissart's remark that it was the habit of defenders to pull off their caps or produce cloths and derisively dust the masonry when it was struck by stones.

In the Siege of Auberoche (1344), the battering stones are described as producing a noise like thunder, and it is stated that they destroyed roofs, tiles, and the principal buildings.

The famous thirteenth-century French architect, de Honnecourt, describes a counterpoise sand box, weighing 8 to 9 tons, and recommends one 12ft. long, 8ft. wide, and 12ft. deep. The building of one at Acre required 200 cartloads of material, and one for the Siege of Stirling, which hurled stones of 2 cwt. and 3 cwt., was erected by fifty carpenters and four foremen, who worked for some weeks.

P.V.C. CABLES.—Since the loss of our rubber supplies to the Japanese, the electric cable industry has saved large quantities of rubber by substituting polyvinyl chloride coverings. It is calculated that these savings already amount to some thousands of tons a year. Owing to this increasing use of P.V.C. compounds for cable-making purposes there has arisen a heavy demand for certain compounding ingredients, and it is therefore necessary to exercise the most stringent control over their use. To achieve this, the Plastics Control and the Cable Planning Organisation of the Ministry of Supply have decided to standardise polyvinyl chloride compounds for general and specialised cable manufacture. The advantages claimed for this scheme will be twofold: first, the reservation of essential materials; and secondly, a guarantee to purchasers that polyvinyl chloride cables to any specification will be made from compounds of the standard required regardless of the source of manufacture.

The Engineer

DECEMBER, 24, 1943

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INTELLIGENT INTEREST IN THE WORKER

PROBABLY if we were strictly honest, all of us at one time or another, when reviewing our performance of "the trivial round, the common task," would admit that we had experienced a feeling of frustration, wondering what the real worth of our efforts was, what their permanent value, and the extent to which our fellow-men had benefited by our exertions. Our perspective is necessarily limited, and it is not given to us to see the end from the beginning. Similar sentiments often reveal themselves in the management of an organisation, which, to take a simple example, may writhe under the manifold statistical and other returns by which it is harassed, and rebelliously assert that they cannot possibly be required, and are of no earthly use to anyone. If these critics could but go into the office of one of those production departments which are charged with providing the Services with their equipment, they would see how all the returns are dovetailed together, and would also appreciate how, with the information carefully collated, it becomes possible to keep a finger on the pulse of industry, to locate weak spots, and also to ascertain which works give the highest efficiency and can therefore be used as an inspiring example to laggard firms. Truly has it been claimed that "to know all is to forgive all."

If senior officials have their misgivings, it behoves us to evidence a very sympathetic attitude towards the man and woman at the bench or machine whose energies and consequent output are often seriously reduced by the demon of doubt who insidiously suggests that their effort is unnecessary, or that they are expected to be pernickety just to satisfy the whims of a foreman whom they regard as unreasonably precise. Much has already been done to interest the worker in the value of the particular article he or she is producing, and it is becoming the rule rather than the exception to display pictures and diagrams of the completed assembly, showing graphically how it functions, and what are its uses. The fact is stressed that the safety of a chain lies in its weakest link, and that each component, however humble, has its place in the scheme of things. In the case of weapons of war, visits of selected workpeople to artillery ranges are planned so that they see for themselves the actual proof, and these visits have certainly had an inspiring result. There is, however, another side that has not had the attention bestowed on it that it deserves; we mean the quality or finish that is demanded by the use to which an article is to be put. Most operatives have a way of comparing notes, and while one is having impressed on him that in wartime there is no justification for polished surfaces, and that he must always bear in mind the term "war finish"—the bane of the true craftsman—he learns with amazement that his mate has been getting into trouble for not reaching the degree of "super finish" required by his foreman. After talking together they come to the conclusion that it is a mad world and that the sooner all foremen are made to speak the same language the better for everyone. It would certainly be of immense advantage if the foremen could be encouraged to put themselves in the position of the staff they control and realise their outlook in a more understanding manner. No one better than the foreman could emphasise the great importance of certain work on an aeroplane, and it would carry conviction if he informed his people that the slightest roughness on the body of a Mosquito might make all the difference between the destruction or escape of the enemy bent on bombing British homes. He might draw the analogy of the pre-war streamlining of English locomotives, with the elimination of all excrescences, with the smoothest surfaces everywhere, in the endeavour to increase speed, and suggest that still more attention was necessary in a machine moving five times as fast as the steam engine. He should have no difficulty in pointing out the difference between the finish that is given to something merely to please the eye and that which is vitally essential if the last ounce of performance is to be obtained. The degree of super finish that is often necessitated by fast-moving machines to ensure perfect balance is understood by the designer, but rarely appreciated by the workman, and an explanatory word by the foreman may prove invaluable. Indeed, we would go further and suggest that before a new article is put into production the foreman might be allowed the use of the apprentice classroom or other suitable place and give an informal talk to his team.

While we should not in any way desire to minimise the importance of a foreman being able to give cogent reasons for the finish required, some firms have gone a stage further by putting the operator himself into the position of having to know, so that he can pass on the true story to others. In order to interest the office staff a certain firm arranged for the girls to tour the works in parties, with the opportunity of asking questions. They were found to raise such intelligent queries that the men and women on the machines realised that in self defence they were being driven to find out more than they ever knew before. Intelligent interest gives birth to new desires, and in the particular case mentioned the girls from the office found the story of the product so satisfactory that they sought permission to undertake part-time work in the shops after their day in the office. These may be isolated instances, but they are cited to suggest a new line of thought, and to prove the great value of everyone knowing the reason, not only for doing what he or she is doing, but also for doing it in the particular way ordered, even though it might at first glance appear to be wasteful or extravagant.

Extravagance and Industry

FOR three years and more we have all been practising the closest economy in personal expenditure. We have not done so willingly, but with resignation. State taxation has taken from us nearly all the money not required for essentials, and the coupons have done the rest. Even in those strata of society where there is more money in the pocket than ever before, the seductions of the squander-bug have been countered by the controls instituted—with considerable success—to prevent reckless spending and consequent inflation. All our habits have been changed, and even our manners have been undermined. Our Victorian grandmamas, looking down from their very genteel Olympus, must be horrified when they see us "scraping the pattern off our plates," "leaving nothing for manners," and chasing the last drop of succulent gravy with "sippets." Such things were positively not done in their time. Then it was polite to be extravagant and the person who troubled his head about small details of economy was "vulgar." As industries grew, we were being constantly urged to be more and more extravagant; they could only be maintained in healthy existence if more and more people bought more and more. Merchants and manufacturers sent their agents from door to door to induce people to spend, and introduced the deferred payment system to enable them to do so. The life of industry depended upon the rate at which money circulated through its arteries and veins.

When peace comes back again we shall

have, in the interest of trade, to jettison the economical habits we have learnt under the stress of war. No longer will the squanderbug be a venomous microbe, but a beneficent nitrogen-producing bacterium encouraging the growth of industry. The catchwords that disfigure our national monuments will be reversed. They will not adjure us to "Save to win the war," but to "Spend to save the peace." The revival of trade, and consequently the volume of employment, will depend in a very large measure on the rate at which money is circulated. Thrift will only be a virtue if the money saved is put back into industrial capital. The industrial capital will be used to increase the means of production, and more and more spenders will be required to consume the output. When Detroit was increasing its productive capacity, its spokesmen used to say that it was the duty—the duty, mark you!—of every good American to own five motor-cars—one for each member of a five-unit family! That did not seem to American eyes so fantastical as it does to ours. In those days America spent lavishly always on the assumption that the more money spent, the more there would be to spend. Our economists of those days preached the same doctrine; they asserted that the cause of trade depression was underconsumption, not over-production.

We shall come back to that position in due time. All the industries that are now mainly engaged on war work will seek markets for peacetime products, and purchasers at home and overseas will be urged to spend and spend and spend. But for some time control is inevitable, and our rate of industrial recovery will depend very closely upon the wisdom with which control is exercised. It is probable that the State having got a grip upon industry will not very willingly let it go, and there will be many stout tussles before liberty is recovered. Industrialists will have to fight for themselves, and oppose excessive taxation and restrictions on their individual efforts. As far as wasting assets, like fuels, are concerned, they may agree that national regulation is desirable, but in the case of manufactures they will demand liberty to expand their own markets and to encourage by all reasonable means the revival of the love of spending which has been so long suppressed.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

OIL ENGINE OUTPUTS

SIR,—I think if Mr. Woodcock tries my formula on a few oil engines of known dimensions and performance he will find my letter was justified. I must apologise for the word "double-acting"; it should have been "ordinary." Your other correspondent, Mr. P. Jackson, proposed exhaust temperature as "a reliable index of the rating." Can he suggest a formula on this basis?

C. F. DENDY MARSHALL.

Guildford, December 17th.

SIR,—Mr. P. Jackson's letter in your issue of December 10th calls for some comment, though I am inclined to agree with his thesis. It should be made clear that the range of temperature cited is applicable only to engines operating on the four-stroke cycle.

The exhaust temperature for the modern two-stroke cycle engine may be 20–30 per cent. less. For instance, on the latest Petter superscavenge (Series V) 8½in. bore by 13in. stroke, two-stroke cycle engine, the exhaust temperature at the B.S.S. twelve-hour rating of 75 B.H.P. per cylinder at 500 r.p.m. (80·5 lb. per square inch B.M.E.P.) is 555 deg. Fah., as compared with 820 deg. Fah. mentioned by Mr. Jackson. Even on the earlier Series IV engines with a B.S.S. twelve-hour rating of 62½ H.P. per cylinder at 500 r.p.m. (67·1 lb. per square inch B.M.E.P.) the exhaust temperature is only 640 deg. Fah.

C. B. M. DALE,
Chief Engineer, Petters, Ltd.

Loughborough, December 14th.

WORKSHOPS FOR ALL

SIR,—What a delightful and inspiring message is contained in your Leader! The happiness to be found in practical hobbies is limitless, and much can be done in selling the idea to the younger generation. Appreciating this fact, my company has inaugurated an annual exhibition of work. We call it a conversazione, and for three hours on a Saturday afternoon we mix speeches, scientific curiosities, tea, handicraft competitions, music, and presentation of awards for educational achievement. The directors of the company, including the chairman, the senior officials, with representatives of education, enjoy themselves with the boys and their parents. The enthusiasm on these occasions must be seen to be believed, and, as for surprises, the polished and eloquent speech of a boy aged eighteen competes with the excellence of a scale-model locomotive embodying five years of happy leisure. What does it matter if the average I.Q. of the prize winners in the model aeroplane competition is below that of the research juniors who fascinate us with their chemical gardens and electrical gadgets. The great thing is that here is happiness in achievement, the basis of this country's greatness. Let industry encourage the idea; it means much to our future welfare.

P. DUNSHEATH,
Director and Chief Engineer,
W. T. Henley's Telegraph Works Company, Ltd.

Dorking, December 20th.

Sixty Years Ago

THE FIRST PROFESSOR OF NAVAL ARCHITECTURE

EVEN more notably than in the case of the locomotive, the art of shipbuilding was evolved by practical men with substantially no assistance from theoretical science. Ships were built and sent to sea, right down to the 'eighties of last century, without the elaborate calculations of their strength and stability characteristic of modern practice. The principle of Archimedes was perhaps the chief and almost the sole weapon in the shipbuilder's scientific armoury. For the rest, long tradition and inherited rules of thumb were the main factors governing the design and construction of ships. The disaster to H.M.S. "Captain" opened the eyes of those who wished to see to the inadequacy of current naval architectural science. The disaster to the "Daphne" drove the lesson home. Nevertheless, while the unsatisfactory state of the art of shipbuilding was widely recognised, the means of improving it were largely lacking. Round about the same time two events occurred which laid the foundations of scientific ship designing as we know it to-day. One was the invention by Amsler of the planimeter, an instrument which placed in the hands of all shipyard draughtsmen a simple means of effecting calculations which previously had been omitted or largely neglected because of their difficult and tedious nature. The other was the establishment in December, 1883, of the first Chair of Naval Architecture at any British university. That Chair was founded at Glasgow University by the widow of the late Mr. John Elder, the Clyde shipbuilder. Its first occupant was Mr. Francis Elgar, previously a consulting naval architect and marine engineer in London. It was a happy choice. Elgar had taken a prominent part in the inquiries into the capsizing of the "Daphne," the mishap to the "Austral," and other marine accidents which had recently emphasised to all concerned the inadequacy of existing naval architectural science. Together with Froude, William White, and others of his contemporaries, he laboured successfully to place it on the basis which it now enjoys.

Personnel of Electricity Supply

AT an informal discussion recently held at the Institution of Electrical Engineers, Mr. G. V. Harrap expressed the view that the electricity supply industry as a whole paid too little regard to the training of engineers, but seemed to expect experience to be obtained elsewhere by some means unknown. On some of the larger undertakings there was movement of junior engineers from one section to another, which enabled the more enlightened undertakings to build up an efficient staff. Nevertheless, there appeared to be a very great lack of clearly defined duties in many undertakings for such men as charge engineers and mains engineers. Yet they were usually judged to be key men, not only for the technical side of the undertaking, but as focal points around which the administrative structure was built. He put forward the suggestion that, just as the generating engineer had had his day, so it appears now that the vogue of the distribution engineer was passing and the star of the administrative engineer might be in the ascendant. Money being the most popular measure of the efficient operation of a concern, the task of co-ordinating the various sections of electricity supply had been increasingly undertaken by those skilled in financial, legal, and commercial subjects, men now coming to be known as administrative officers. Whilst offering no objection to that practice, he stressed the need for technical knowledge and administrative ability on the part of those men. Unfortunately, the majority of engineers had tended to remain purely technical, but Mr. Harrap suggested that the best managers for electricity supply were those men who had had the training in clear and logical thinking that came from engineering experience, upon which could be superimposed administrative ability. Pointing out that management was becoming highly specialised, he asked whether the position was to be that in future young engineers would start their careers with the knowledge that at most they would become sectional chiefs only. It might conceivably be so, and the future reduction in number of undertakings, coupled with the lack of administrative knowledge and ability in the majority of engineers, would not only reduce opportunities for young engineers to become chiefs, but might result in others, more competent in management problems than they were, getting the jobs.

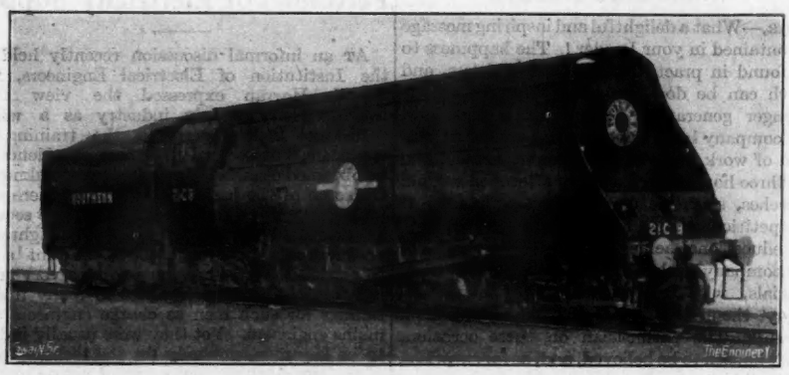
BAUXITE RESEARCH.—The U.S. Bureau of Mines is speeding up the development of alumina-bearing earth materials and low-grade bauxite, in an effort to render the country independent of foreign sources of raw material for the production of aluminium. A grant of 500,000 dollars has been given by Congress to this end, and seven laboratories and pilot plants have been assigned to the work. Canada has a potential source of alumina in the extensive deposits of nepheline cyanite, and experiments already conducted have indicated commercial success on a production basis, but, so far, nothing has been done to further this project. The Government has refused priorities for the necessary plant construction material.

Southern "Pacifics" at Work

By W. A. TUPLIN, D.Sc., M.I. Mech. E.

No. I

WITH so much of the world's ingenuity at work on engines of destruction it was specially refreshing to find, when details of the Southern Railway's first "Pacific" type of locomotive were published in 1941, that thought could still be spared for peaceful purposes. Not since the early days of Churchward's *régime* on the Great Western Railway has any railway in this country produced a successful design that embodied so many features new to British practice. It is true that some of the novelties affect only what may be called details, but their cumulative effect is great, and Mr. O. V. Bulleid, chief mechanical engineer of the Southern Railway, must have had no little courage to incorporate them all in one entirely new design.



SOUTHERN RAILWAY—"MERCHANT NAVY" CLASS

Of the special features of the "Merchant Navy" class engines, the following are perhaps the more important :—

(1) Oil-tight enclosure of all valve gear and of running gear for the inside cylinder.
(2) Bulleid patented valve gear designed to facilitate complete enclosure.
(3) Two thermic siphons in fire-box.
(4) Light cast steel wheel centres of the double-disc B.F.B. type.
(5) Power-operated fire-door of the "Ajax" type.
(6) Clasp brakes for the driving wheels.
(7) Water-filling holes at front of tender.
(8) Multiple-jet blast pipe.

Enclosure of Motion

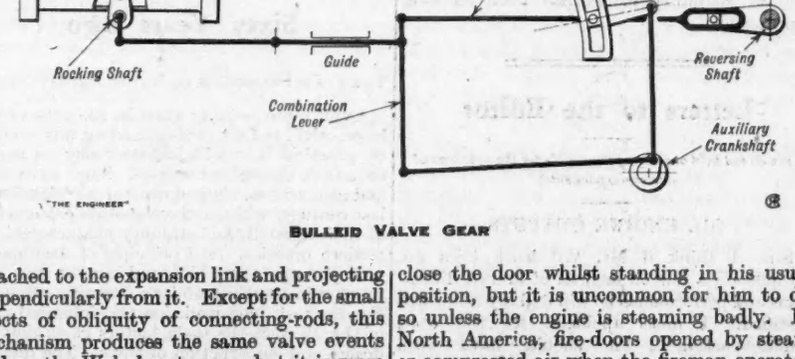
It is well known that properly designed bearing surfaces correctly lubricated and kept free from dirt may be run almost indefinitely without suffering appreciable wear. In the conventional steam locomotive most of the mechanism works in conditions far removed from this ideal and relatively heavy maintenance costs are inevitable. In the Southern "Pacific" a notable departure from standard practice has been made by fitting a sheet steel sump beneath the main mechanism that lies between the frames, and similarly protecting it on the upper side so that it is contained in a dustproof, oil-tight enclosure. The connecting-rod big end thus has dip lubrication, whilst the little end, the slide bars, and the valve gear are fed with oil partly by splash and partly by pipe feeds from gear pumps.

Whilst the protection thus provided for the working parts is bound to increase their effective life considerably, it makes examination and repairs appreciably more difficult when they do become necessary, and so it required a bold confidence to adopt the scheme, besides a high degree of technical skill to carry it out in detail.

Bulleid Valve Gear

Although it might not be impossible to fit three sets of Walschaerts valve gear between the frame plates of a three-cylinder locomotive, it would involve some restriction of length of axle journals and width of big-end bearing. The Bulleid valve gear is basically the same as the Walschaerts gear, but it derives its movements, not from an axle and crossheads, but entirely from an auxiliary crankshaft that is rotated by the driving axle through a one-to-one chain drive.

There is one crank for each cylinder and each crank drives two connecting-rods. One of these lies substantially parallel to the axis of the piston valves, and controls the lower end of the combination lever. The other lies substantially perpendicular to the first and controls the outer end of an arm rigidly attached to the expansion link and projecting perpendicularly from it. Except for the small effects of obliquity of connecting-rods, this mechanism produces the same valve events as does the Walschaerts gear, but it is more compact and more suitable for complete enclosure.



BULLEID VALVE GEAR

The valves are of the outside admission type, and each one is moved, not by the usual spindle, but by an arm carried by a rocking shaft situated in the central exhaust chamber. The shaft projects through a gland in the wall of the chamber and the outer end has an arm oscillated by the valve gear. The end of the inner arm lies on the centre line of the valve in the slotted hollow distance piece between the valve heads, and it is connected to the valve by a link and a cross-pin near to the forward end of the distance piece. With this arrangement there is no gland subjected to live steam pressure.

Thermic Siphons

The application of the thermic siphon to locomotive fire-boxes is common in America, but it had hardly been tried in this country before its inclusion in the first of the "Merchant Navy" class. British reluctance to adopt this feature is understandable, for it involves the use of a steel inner fire-box instead of the copper box long favoured here, and it is a somewhat awkward addition to a part of the locomotive where operating conditions are most severe, and where the consequences of a failure may easily be fatal. Nevertheless, Mr. Bulleid has gone boldly forward to fit two thermic siphons in each "Merchant Navy" engine.

The advantages of the thermic siphon are that it augments the effective heating surface of the boiler without perceptible increase in resistance to flue gas flow and that it tends to invigorate circulation of water in the boiler as a whole. The strong convection current through the siphon is claimed to safeguard against the dangerous consequences of "low water" by flooding the crown sheet of the fire-box.

Double-Disc Wheels

The box-spoke type of wheel used under the Southern "Pacifics" is a fairly common feature in American high-speed locomotives, and, contrary to its appearance, its advantage over the conventional cast steel wheel is that of lightness. To British eyes, these wheels have a somewhat lumbering appearance, by contrast with the usual narrow-spoked cast steel wheels, but this is largely a matter of personal taste and has no practical significance.

Power-Operated Fire-Door

When a locomotive is being fired whilst working heavily, it is easier to maintain steam pressure in the boiler if the fire-door is kept open only for the time necessary to admit the shovel and its charge of coal. Some British locomotives have the fire-door handle placed so that the driver can open and close the door whilst standing in his usual position, but it is uncommon for him to do so unless the engine is steaming badly. In North America, fire-doors opened by steam or compressed air when the fireman operates a pedal have been used for many years, and the first British application of them is in the Southern "Pacifics."

The "Ajax" fire-door is in halves, which meet, when it is closed, on the vertical centre line of the fire-hole. The application of steam pressure to a cylinder causes the two halves to swing away from one another about horizontal axes near to their top edges, so that they leave the fire-hole exposed. The doors are hollow and are pierced by a number of

holes, through which air reaches the fire-box even when the door is closed. It is intended in the "Merchant Navy" class that the door should normally be kept shut except for the few seconds necessary to admit each shovelful of coal, and no internal deflector plate is provided.

By using a long handle which projects from the control mechanism the fire-door can be set to remain partly open in any one of four positions, giving different degrees of admission of air above the fire.

CLASP BRAKES

The coupled wheels of the engine have brakes which apply equal and opposite horizontal pressure to them. This involves brake gear which is slightly more complicated than the conventionally designed mechanism, but it is deemed to be offset by the superior efficiency of the clasp brake. The tender is also fitted with this type of brake throughout.

WATER-FILLING HOLES

It is customary to fill locomotive tenders with water through a manhole situated near the back. The fireman can reach this hole only after some climbing either over the coal or by steps up the back of the tender, and his struggles with an obstinate hose are apt to be perilous.

The tenders attached to the South "Pacifics" have no water scoops and so all water has to be passed into them through a leather hose or its equivalent. To make it unnecessary for the fireman to leave the cab when the engine is to take water, the filling holes are placed at the front end of the tender and are easily accessible from the footplate. It is hard to find why this has not previously been done in this country, for the scheme appears to be entirely advantageous, except perhaps that a leaking hose may spray the interior of the cab to an unwanted extent.

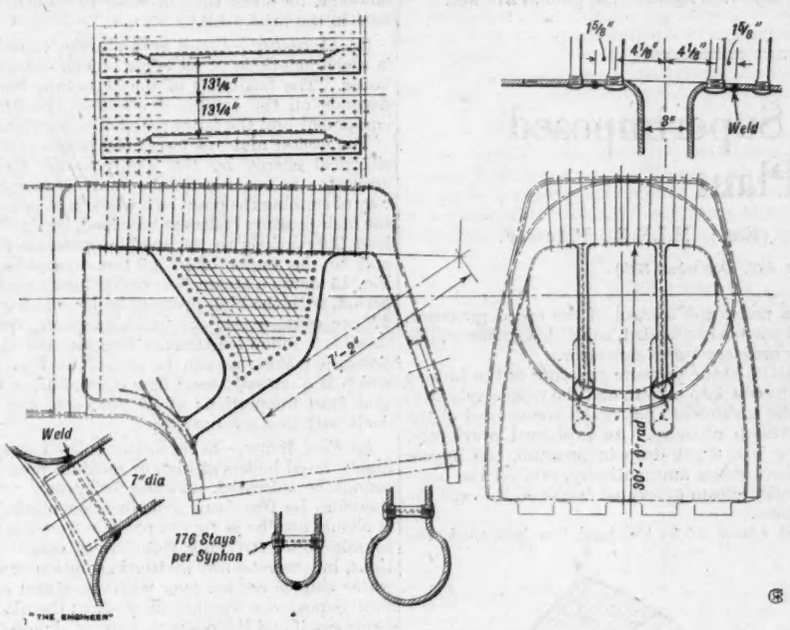
MULTIPLE-JET BLAST PIPE

The "Merchant Navy" chimney is of unusually large diameter and the exhaust steam passes through five nozzles, set so as to induce a flow of flue gas over its entire cross section and thus to develop a high degree of smoke-box vacuum for a given steam discharge rate.

Of British railways, only the Southern has seriously experimented in this direction, and it has been shown that the multiple-jet blast pipe, if correctly designed, gives lower back pressure than would be set up by a single-jet blast pipe of the same inductive capacity. Consequently, the multiple-jet blast pipe has gradually been becoming the standard chimney on the Southern Railway, and it has been fitted to all the "Merchant Navy" engines as a matter of course.

DIMENSIONAL DISTINCTIONS

Among the other notable features of the Southern "Pacifics," attention may be drawn to the short piston stroke of 24in. and the working pressure of 280 lb. per square



SOUTHERN RAILWAY—THERMIC SIPHONS

inch, which is 30 lb. per square inch higher than that of any other standard British locomotive. The driving wheel diameter of 6ft. 2in. is more in line with British practice for "mixed-traffic" engines than for high-speed work, but there is no reason to believe that the "Merchant Navy" class will have any difficulty in running fast when necessary.

There has apparently been a determined effort at weight reduction in designing this locomotive, for it is approximately 10 tons lighter than the L.N.E.R. streamlined "Pacific" of Class "A.4," which is of generally similar dimensions, but works at the lower pressure of 250 lb. per square inch.

GENERAL APPEARANCE

Although streamlined locomotives are no longer an uncommon feature of British railways, it is doubtful whether they inspire any widespread enthusiasm. In the writer's opinion, the outward appearance of the Southern "Pacifics" is marred by the "streamlined" or "air-smoothed" casing that encloses the boiler. Streamlining has a perceptible effect in reducing air resistance at speeds higher than about 70 m.p.h., but it has also been accorded some publicity value because of its tendency to persuade non-technical travellers that it represents something new. It has apparently been forgotten, however, that the conventional steam locomotive has a strong emotional appeal even to casual observers, and they greet a streamlined engine somewhat coldly, because they "like to see an engine that looks like an engine." A Southern "Pacific" in non-streamlined garb would still be a locomotive of striking appearance, and there is reason to believe that many people would prefer its undisguised outline to the artificial starkness of the "Merchant Navy" class as now running.

(To be continued)

Quality Control

AT the Institution of Mechanical Engineers on Friday, December 17th, a symposium of papers on Quality Control was presented and discussed. We reproduce below summaries of the three papers.

INSPECTION EFFICIENCY

By J. C. EDWARDS, B.A., and W. A. BENNETT*

The purpose of the paper is to outline the numerous directions in which improvements can be sought in engineering inspection. It shows how direct improvements in efficiency can be effected by carefully planned methods of recording results, including the use of statistical quality control, by adopting the principles of time and motion study in the planning of flow of work through inspection and in the design of gauging fixtures and the arrangement of gauges. The importance of correct personnel selection and organisation is stressed, as is also the avoidance of duplication of inspection. The paper concludes by quoting figures showing the substantial reductions which have been achieved in the authors' company by a progressive application of the methods described over a period of several years.

THE APPLICATION OF STATISTICAL METHODS TO THE CONTROL OF INDUSTRIAL COSTS

By NORMAN R. NEAL, M.I. Mech. E.†

Quality control studies the variation from standard of tangible articles, whereas "cost control" studies the variation from standard of the workers' efficiency, and consequent variation in production cost. In essence, the system consists in setting standard times, and thus standard costs, for all jobs, and for the elements making up the complete jobs. Percentage divergencies from those standards are recorded at regular intervals on charts, a separate chart being used for each class of work, both as regards time and cost.

Control lines, calculated from previous results over a period, upon the same mathematical principles as for quality control, are inserted on on the charts. When a reading falls outside the control line, action must be taken to ascertain the cause. However, unlike quality control in which articles covered by abnormal readings can be scrapped, abnormal time or cost must still figure in the final examination of production cost. A sufficiently fine subdivision of the elements of a job will prevent an occasional abnormal reading on one portion from giving abnormal reading for the complete job.

The individual readings are combined to form a grand total chart. Careful watching of the detail charts enables the grand total chart to be maintained in control, and it is from the latter chart that the "cost index" (percentage divergence from standard of the cost of the complete product) is obtained, which enables the latest actual cost at a particular moment to be determined directly. A continuous check is thus kept on the production cost of all the principal details. Any abnormal fluctuations of cost become quickly apparent, and can be readily traced back to their cause. Concurrently, a simple method is provided for obtaining the total actual cost of the complete product at any time.

SAMPLING SCHEMES FOR QUALITATIVE INSPECTION

By A. W. SWAN, B.A.Sc.‡

The paper opens with a description of the applications of "qualitative" inspection. Briefly, it is used where "quantitative" inspection, or inspection by direct measurement

* Chief engineer and chief inspector respectively, the English Needle and Fishing Tackle Company, Ltd., Studley, Warwickshire.

† Joint managing director, R. H. Neal and Co., Ltd.

‡ Ministry of Supply.

on a continuous scale, is impossible, as in the case of a destructive test or a visual inspection for blemishes, or as an economical alternative through limit gauges to "quantitative" inspection.

The industrial and theoretical factors affecting the choice of a sampling scheme for qualitative inspection are discussed, particularly producer's risk (the risk that good material may be rejected), and consumer's risk (the risk that bad material may be passed). It is pointed out that a sampling scheme can be devised to give an agreed maximum producer's and consumer's risk. It is shown that the maximum allowable percentage of defectives cannot be set in an arbitrary manner, but only after consideration of the process average percentage of defectives. If the ratio of the maximum allowable to the process average is too low (*e.g.*, if the requirement is too severe), the minimum sample size for reasonable producer's and consumer's risk is impossibly high.

A simple chart is provided, from which, with the industrial factors limiting the size of lots and the size of samples, the desired percentage of inspection, and the process average percentage of defectives as the "known" quantities, it is possible to read off the best single or double sampling scheme to give agreed maximum producer's and consumer's risks. The chart gives the best size of sample and the corresponding "pass up to" number of defectives per sample.

The paper concludes with instructions on when and how to change to more severe sampling conditions, when results from successive samples show a deterioration in quality from the process average, and discusses the need to keep the new conditions in force until there is satisfactory evidence that the quality has improved again to the process average.

A High-Pressure Superimposed Power Plant

By D. RONALD WILLIAMS, B.Sc., (Eng.), M.I.E.E., F. Inst. F.

No. IV—(*Continued from page 483, December 17th*)

(9) Operating Procedure

(*a*) *Starting Up and Shutting Down.*—When starting up the boiler from cold the automatic feed valve 1, injection valve 2, and by-pass valve 6 (Fig. 3 *ante*) are under-blocked by hand to a position corresponding to about three-quarters of the valve opening under normal load, and the intermediate superheater is opened to the feed heater, all other main valves remaining closed. Circulation through the whole high-pressure system, including the superheater, is established by starting up the high-pressure feed pump *a* and the boiler is then fired. The pressure in both the feed heater and the high-pressure system rises, the water in the feed heater is circulated, the intermediate superheater is blown down, and simultaneously cooled, and when the pressure of the feed heater has reached that of the medium pressure system, the boiler is put on range. As soon as the steam temperature at the intermediate superheater reaches its normal value, the medium pressure injection valve 8 operates under the influence of thermostat 9.

Conditions on the high-pressure side may be followed from an actual chart, Fig. 14, which shows (*a*) the pressure, (*b*) the temperature at point 3, and (*c*) the final steam temperature at point 4. Steam pressure and temperature are converted into oil pressures, the ratios being

± 1 lb. oil pressure $= \pm 4 \cdot 3$ lb. steam pressure.

± 1 lb. oil pressure $= \pm 5 \cdot 07$ deg. Fah. steam temperature.

Simultaneously with the lighting of the fire at 8.40, the pressure in the high-pressure system rises sharply, reaching full pressure within a few minutes, and valve 6 starts to operate.

The temperature at 3 and 4 starts to rise, and at about 8.50 the temperature at 3 has reached saturation and remains constant, showing that the feed valve 1 has been underblocked to a higher position than would correspond to the actual load, but which is quite normal for starting. Meanwhile, the temperature at 4 rises, injection valve 2 begins to operate, and shortly after nine o'clock full temperature is reached.

At this stage all the high-pressure steam produced is passed through the feed heater, desuperheated, returned to the boiler, reheated in the intermediate superheater *b*, and delivered to the medium-pressure station range. This condition, which can be maintained for any length of time, allows the full output of the boilers to be generated, even should the high-pressure turbine not be running.

It will be seen from the chart that the high-pressure turbine was started up shortly after ten o'clock. It is first synchronised on to the bars under the control of the speed governor, and can also be loaded, using this governor, like any ordinary turbo-generator.

At 10.30 the pressure governor of the turbine is brought into action, and the nozzle valves 10 of the turbine are put under the control of the admission pressure. As explained previously, there is a slight drop in pressure, the bypass valve 6 closes automatically, and all the high-pressure steam generated is passed through the turbine.

At about 10.45 the load has increased, the

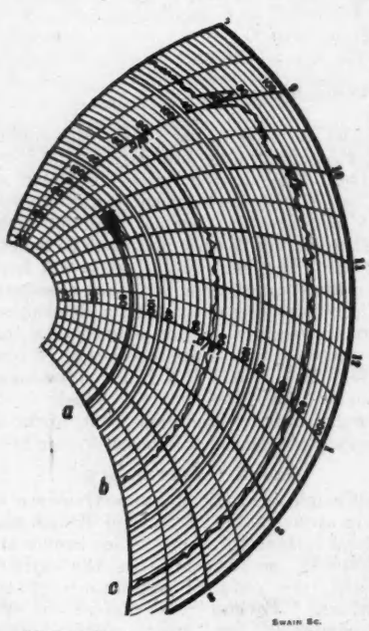


FIG. 14

temperature at 3 rises above the saturation point, and the feed-regulating valve 1 begins to function normally.

In order to bring the second boiler on range, similar procedure is followed, but the distribution of the medium-pressure steam between the two reheaters has to be controlled by ensuring that the steam quantity passing through the first boiler remains constant while the load is also maintained constant. The additional steam is then passed through the second boiler, which receives a quantity of steam corresponding to its heat release.

Although this plant consists of two boilers with flue gas steam reheaters operating one high-pressure turbine, steam distribution has never given rise to any difficulties. If convenient, both boilers are normally kept on approximately equal load, slight variations in the medium-pressure steam temperature being adjusted by the automatic injection 8. Except in case of considerable differences of load between the two boilers, it is unnecessary to operate the distribution valve.

The operations are reversed when the boilers are shut down. As the fires die out the injection valves close automatically following the drop in temperature, and the feed is automatically reduced. The drop in steam temperature causes the valves 5 to close, and the boiler discharges through the by-pass valves 6 to the feed heater. Circulation is maintained, however, for some time in order to absorb the heat in the brickwork.

(*b*) *Flexibility.*—Small heat storage capacity is a characteristic of all types of high-pressure boiler. The flexibility of the Monotube boiler depends on the combined effect of the firing equipment and the automatic boiler regulation.

The easiest and—as far as the production of electrical energy by the high-pressure turbo-generator is concerned—the most economical way of running the plant as a whole is to operate the high-pressure boilers at base load, leaving the load fluctuations to the medium-pressure side and to the buffer effect of the accumulator. Fig. 15 shows a steam flow chart during such a period, with the high-pressure boiler running at 27 per cent. overload. It is, however, quite possible to follow load fluctuations with the high-pressure boilers, as can be seen from Fig. 16, which is a normal steam flow chart, and shows that load fluctuations of 30 per cent. can be dealt with in a few minutes.

(*c*) *Feed Water.*—Scale in the boiler tubes of highly rated boilers of high or medium pressure cannot be tolerated, and the feed water must therefore be free from scale-forming hardness. It should also be as free as possible from highly soluble salts, not only from boiler considerations, but because any matter in solution in the water can be carried over with the steam and form deposits on the turbine blading, the blades being small and the passages narrow, due to the low specific volume of the high-pressure steam. The feed water should, of course, contain a minimum of absorbed gases in order to avoid corrosion.

As already shown, the make-up is produced by distillation. There are two evaporators *l*, which can operate singly or in cascade, the feed water being de-gassed in a de-aerator *n*, by heating to nearly boiling point with exhaust steam.

In view of the importance of satisfactory feed water, a permanent system of control has been adopted, consisting of a Dionic recorder recording the electrical conductivity of the water. The instrument is connected up in such a way that it can be alternatively connected to any water source in the station, *i.e.*, to each of the six condensers, to the evaporators, and to the feed water.

Normally the instrument records the high-pressure feed, and should it show any irregularity, the origin of the contamination can be ascertained by switching over to the individual water sources and thus leaking condensers, priming evaporators, &c., can be detected.

Fig. 17 shows a salinometer record taken during the starting-up period of a boiler. Circulating water through the high-pressure tube system, including superheater, increases the conductivity, which went up to 34 conductivity units. The concentration of the feed water afterwards fell back slowly, due to the supply of condensate to the feed heater, and in an hour's time it was almost back to normal, but the disturbance was visible for several hours. When the condensers are in good condition and everything else in order, the conductivity of the feed water is about $1\frac{1}{2}$ to 4 units (1 conductivity unit equalling $1 : 10^6$ ohm per square centimetre per centimetre, corresponding to approximately 0·044 grain per gallon in Na_2SO_4 solution). Under less favourable conditions a conductivity of 4 to 8 units can be expected.

Apart from the Dionic records, the water is regularly tested by chemical analysis.

(10) Protection Following Abnormal Occurrences

(*a*) *Failure of High-Pressure Feed Pumps.*—Should the feed pumps fail, due to any cause, the fire must be extinguished immediately. Signal arrangements on the boiler control board indicate the failure of the feed supply instantaneously. The tube system, to which heat is transferred from the hot brickwork, is protected by slowly opening the bypass valve 6, allowing steam to escape to the feed heater and the boiler pressure to drop. Consequently the water contained in the boiler flashes to steam and the steam flow through the system is established. It has been proved under working conditions that this method is quite safe in cases of emergency and that the water content of the boiler system is sufficient to ensure effective cooling of the tubes.

(*b*) *Failure of Water Supply to the Feed Heater.*—If the water level in the feed heater drops below a certain point, valve 13 automatically opens, connecting both the medium-pressure feed line and the water at the bottom of the feed heater to the suction of the high-pressure pumps. The water content of the feed heater can then be utilised, allowing one boiler to steam at normal load for about three-quarters of an hour. Faiure of the water supply to the feed heater is a most unlikely contingency, as the station is equipped with six medium-pressure electrically and steam-driven boiler feed pumps connected to a duplicate feed range.

As the water level in the feed heater can be hand controlled, failure of the automatic level regulator would not cause any serious inconvenience. Water level indication is provided by means of a mercury type indicator adjacent to the feed valve.

Should the water level in the feed heater rise above a predetermined point, an automatic blow-down valve is opened which discharges the water into the hotwells.

(*c*) *Failure of Pressure Oil Supply for Boiler Regulation.*—Two oil pumps have been provided for supplying the pressure oil necessary for the boiler regulating equipment. One is a motor-driven gear type pump, and the standby a steam-driven duplex pump. The latter is always kept working very slowly and is provided with an automatic steam admission valve, which opens should the oil pressure drop below a certain limit and the pump runs up to full speed instantaneously. Failure of the pressure oil supply is therefore most unlikely.

Nevertheless, should the oil system fail following damage to the oil pipes, the automatic valves will close. (These valves are normally kept open by the servomotors against the forces exerted by the flow.) The safety valves would then commence to blow, and if steam production is to be maintained the automatic valves should be underblocked by hand and the fire controlled according to the steam pressure, as on any ordinary boiler.

(*d*) *Failure of High-Pressure Turbine.*—Should the high-pressure turbine trip out the by-passes to the feed heater open automatically and the method of operation without the high-pressure turbine which has already been described is established. If the electrical load carried by the high-pressure turbine is picked up by the medium-pressure turbines, there is no difficulty and no loss of steam occurs. This was demonstrated before the plant was taken over.

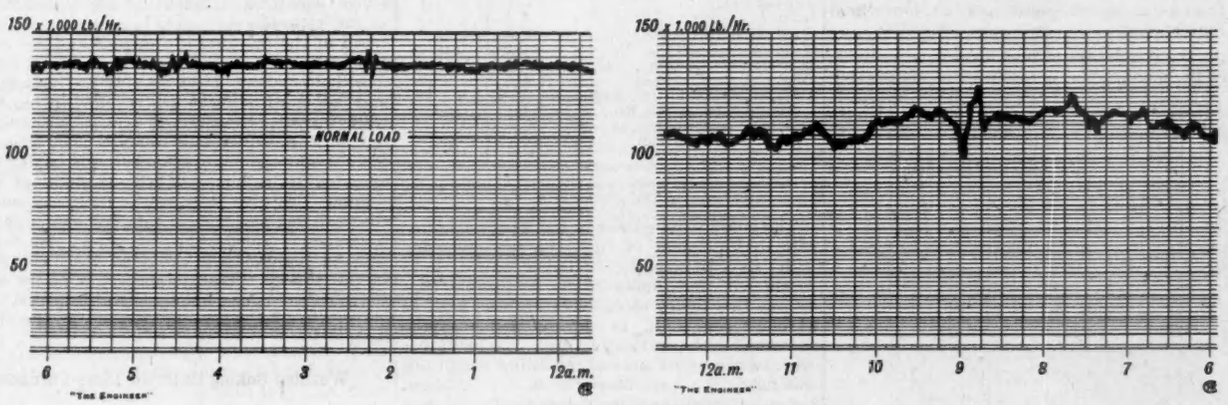
(11) Flushing of Boilers

Flushing is carried out in order to clean the tube system when necessary, *e.g.*, after a long uninterrupted run, or if the feed-water conditions have been unsatisfactory, and is effected as follows :—

The boiler is isolated from the high-pressure turbine and its feed supply gradually increased. The steam temperature falls to the saturation point and water is then passed through the whole system, including the superheater. Washing out with boiling water at 1500 lb. per square inch pressure proved to be a most effective method of cleaning and the effectiveness can be readily observed from the Dionic recorder.

(12) Operating Experience

The boilers were both commissioned by August, 1938, but a series of delays were experienced in carrying out minor modifications, which delayed the taking over of the plant until 1939. Since this date the plant has given most satisfactory service, the only troubles were such as might have occurred with normal natural circulation boilers operating at the more usual pressures. Combustion conditions have been excellent and it is possible to operate the boilers for twelve months without any cleaning of the heating surfaces, other than that affected by the soot blowers which are operated daily.



FIGS. 15 AND 16—STEAM FLOW CHARTS

(13) Conclusions

The main considerations which influenced the decision to install this plant were as follows :

(i) The capital expenditure involved in this type of boiler plant was such that it compared favourably with drum type boilers operating at 350 lb. per square inch.

(ii) The net thermal efficiency of the station would be increased from approximately 16·2 to 20·6 per cent.

(iii) The Monotube generator allowed the installation of two high-pressure boilers, each having a capacity of 130,000 lb. per hour in the same space as that occupied by two of the existing 35,000 lb. per hour boilers, so that the total station capacity would be increased by 190,000 lb. per hour.

(iv) The net load-carrying capacity of the station, after due allowance for auxiliaries, would be increased by approximately 5500 kW, without any expenditure on condensing plant and cooling water arrangements.

(v) As a marketable fuel was to be replaced by a low-priced fuel, there was a considerable saving in fuel costs, additional to the saving due to increased thermal efficiency. It was estimated that the savings would be sufficient to pay for the plant in less than four years.

The savings which were envisaged prior to the installation are being fulfilled. There is an extra 5500 kW of generating plant available for load purposes and a new lease of life has been given to the station as the old boiler plant, which was almost obsolete in relation to modern practice, has been largely replaced. The installation can therefore be said to be without question a successful commercial venture.

From the engineering point of view, the operating results speak for themselves. The regulating equipment, which is perhaps the outstanding feature of the plant, has been extremely reliable and requires very little attention. The plant has been operated by men from the old plant, who have found no difficulty in running it at a high efficiency.

The experience at this station shows that superimposition can be a successful commercial venture (this has also been proved on numerous occasions in America), and there must be many stations in this country, which, following the very heavy increase in the cost of fuel during the last few years, can be superimposed with advantage. Like everything else, of course, it is not possible to make any general rule as to when superimposition is the correct solution and it often depends on local circumstances which call for investigation of each case. It does, however, seem that it is worth consideration when all or some of the following conditions arise :—

(*a*) The station capacity is more than 50,000 kW (in special cases 30,000 kW).

(*b*) The station thermal efficiency is less than 23 per cent.

(*c*) Additional load-carrying capacity is required.

(*d*) There is a shortage of circulating water for condensing purposes.

(*e*) The freight rate on fuel to the station is above the average.

(*f*) Station capacity and/or efficiency is affected by inadequate boiler capacity, which may, in turn, be due to low availability of the existing boiler plant.

(*g*) The station has already served some useful part of its life.

(*h*) The station has a reasonable load factor.

Superimposition has many advantages for the older stations, the more important of these being :—

(1) Additional load-carrying capacity can be obtained without increasing the quantity of water required for condensing purposes.

(2) The capital cost of the increased load-carrying capacity is very little more than that which would be expended upon the equivalent increase in capacity with condensing turbines and boiler plant operating at the lower thermal conditions of the existing plant.

(3) The thermal efficiency can be increased by 20–25 per cent. with considerable saving in the fuel cost. In the case of 100,000-kW station operating at 50 per cent. load factor, thermal efficiency of 21 per cent. and coal cost 30s. per ton, the saving would be from £95,000 to £120,000 per annum.

(4) The useful life of the station can be extended by a period dependent upon its age. In the case of a 100 M.W. station, which has a further ten years' life, superimposition should extend its life by an additional ten years. Assuming the cost of a new station to be £30 per kilowatt, and the annual interest and depreciation charge 8 per cent., there would be a saving of £240,000 per annum for a period of ten years, or a capital sum if this benefit were reinvested at 3 per cent. compound interest of £2,750,000 at the end of this period, which, of course, is almost the cost of a new station.

(5) The old boiler plant could be de-rated to operate with a higher availability and an increased overall efficiency, while the steam temperature on the low-pressure system could be maintained near the designed condition, thereby improving the overall low-pressure steam cycle efficiency.

(6) The station thermal efficiency would be among the highest in the country, and it is fair to assume that a station with high thermal efficiency relevant to other stations would be used as a base load station, and would be allocated a far higher load factor than the assumed load factor of 50 per cent. If the station were allocated a load factor of 80 per cent., it would not only result in a further improvement in thermal efficiency, but the total cost of production per unit sent out would be between 15 and 20 per cent. less than for a station operating at the lower load factor.

At the conclusion of hostilities it is probable that the manufacturing resources of the country

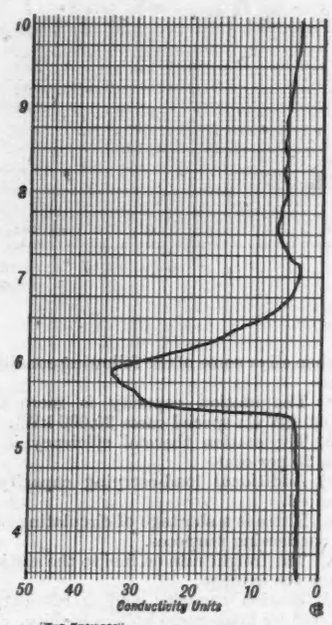


FIG. 17—SALINOMETER RECORD

will have to be carefully husbanded, and every effort will be made to increase thermal efficiency as a means of conserving the country's fuel resources. At the same time, in order to maintain the price of electricity at its present level, notwithstanding the burden which will be imposed on the industry by the heavy cost of new capital works, it will be essential, wherever possible to defer the retirement of large amounts of fixed capital. If therefore it is practicable to extend the life of a large generating station, at the same time increasing its capacity for a capital expenditure little more than that necessary to install the equivalent capacity of condensing plant, and, further, to increase considerably the thermal efficiency of the station as a whole, it should prove a real contribution to the economic stability of the industry, and is therefore worth the most careful consideration.

The author wishes to express his thanks to the management of the collieries and Sulzer Bros. (London), Ltd., for their permission to publish information in connection with this plant.

BOILER TESTS

Efficiency tests of eight hours' duration at normal load and of three hours' duration at peak load were carried out. The tests were made with A Dry Duff on boiler No. 1 and with B Washed Duff on boiler No. 2.

Boiler No. 1 (Coal A)

Load	Peak	Normal
Analysis of coal :		
Net calorific value B.Th.U. per pound	12,040	12,820
Volatile, per cent.	10·9	10·6
Ash, per cent.	16·4	11·9
Moisture, per cent.	3·2	3·4
Fixed carbon, per cent.	69·5	74·1
Steam generated, t/h	64·9	48·5
Efficiency, in net calorific value	83·6	87·0
Efficiency in gross calorific value	81·5	85·2
Air temperature at forced draught fan inlet, deg. Fah.	79	88
Flue gas temperature at air heater outlet, deg. Fah.	315	308

Boiler No. 2 (Coal B)

Load	Peak	Normal
Net calorific value, B.Th.U. per pound	13,280	13,340
Volatile, per cent.	14·6	14·8
Ash, per cent.	6·4	5·1
Moisture, per cent.	6·2	7·3
Fixed carbon, per cent.	72·8	72·8
Steam generated, t/h	66·1	48·4
Efficiency, net, per cent.	87·0	90·6
Efficiency, gross, per cent	84·6	88·2
Air temperature at forced draught fan inlet, deg. Fah.	104	90
Flue gas temperature at air heater outlet, deg. Fah.	329	296

The guaranteed efficiency was 86 per cent., based on the net calorific value at the normal load.

The guaranteed efficiency was easily attained with both classes of fuel, the net efficiency with B coal reaching 90·6 per cent. It is considered that under more favourable conditions this figure could have been as high as 91·5–92 per cent., as during this test the unburnt carbon in the flue dust was 70·15 per cent., while under normal operating conditions this figure is nearer 30 per cent. In addition, the water from the interceptors was taken as a loss, but since the tests it has been found practicable to return this water to the water-softening plant.

The peak boiler load of 150,000 lb. per hour was easily maintained with an efficiency of 83·6 per cent. with the low volatile fuel and 87 per cent. with the higher volatile fuel.

The power consumption of the auxiliaries was less than the guaranteed figures and the draught required was remarkably low, being approximately 2·3in. at peak load and 1·24in. at normal load.

The dust collecting plant was tested by taking samples of the dust escaping up the chimney with a Ter Linden cyclone collector. This apparatus collects a proportion of the dust in the flue gases and the total weight of dust escaping is calculated from the relative areas of the test apparatus and the chimney, and from instrument constants determined by Professor Bauer. Two tests were carried out, the first with a setting to give a draught loss of 1·28in., when an efficiency of 91 per cent. was obtained, and the second with a draught loss of 0·92in. when the efficiency was 86 per cent. The guaranteed efficiency was 85 per cent.

The steam consumption of the turbine had been guaranteed at loads of 6500, 5500, 3500, and 1000 kW. A separate test was made for each of the first three loads and all the steam consumptions were found to be within the guarantee. They were 37·2, 37·8, and 41·0 lb./kWh respectively at a power factor of 0·8.

PLYWOOD PLATE GIRDERS.—Girders with plywood webs and timber flanges are now being used in the construction of buildings in the Detroit area. To transfer stress in the flanges to the web, the members are glued together and maple dowels are added at intervals.

American Engineering News

Enlarging a Marshalling Yard

In order to cope with the enormous expansion of its war and industrial freight traffic, the Norfolk and Western Railroad, U.S.A., has enlarged and practically rebuilt one of its large classification or marshalling yards at a cost of £1,300,000, including new facilities for servicing the road and switching locomotives, and special equipment for expediting the operation of the yard. Receiving tracks for incoming trains are long enough for trains of 110 to 130 wagons of 40ft. length, or a total of 2500 wagons. A double line with "hump" for gravity switching connects the receiving yard with two classification or marshalling yards, having tracks long enough for thirty to forty wagons and providing for nearly fifty different classifications. Beyond are the departure tracks in which wagons are assembled into trains ready to be taken on by the main-line locomotives. Yard engines push the arriving or inbound trains up a gradient of 2·4 per cent. to the summit of the "hump," beyond which there is a gradient of 1 in 40 to the 300-ton track scales, over which it is 1 in 133, and then an accelerating gradient of 1 in 28, which is reduced to 1 in 500 as the tracks diverge to the several classification tracks. Electro-pneumatic wagon retarders or track brakes regulate the speed of the free-running wagons and are controlled by men in elevated cabins. In twenty-four hours about 2000 wagons are classified, and one-third of these are weighed in motion, while in rush or emergency operation the total number can be increased to about 2600 wagons. Signals and communication systems enable the operator in a house at the summit of the "hump" to give instructions to the crews of the yard engines, the car retarder men and the brakemen in the classification yards. Illumination for nightwork is provided by floodlights in tall towers. Train engines are rarely sent to the engine-house, but are cleaned and serviced on open tracks, where 120 engines are handled daily.

Washing Coking Coals for Blast-Furnaces

For maximum production from any given blast-furnace the most important influence is the quality of the coke used, and deterioration of the Pittsburgh coals in the United States is being accelerated by the depletion of the better grades, the increasing use of mining machinery, with degradation of quality, and by the opening of new fields in which the coal is high in sulphur. In view of these conditions and the urgent need for the highest possible production of pig iron, extensive experiments have been made as to improvement of the coals by washing. The investigation relates to high-volatile coals; the improvement in chemical and physical properties, and the degree in uniformity of the coke; and also the effect of coal washing upon blast-furnace production and practice. The general conclusion is that the prospective deterioration in quality of coking coals from this particular district will of necessity involve coal washing, and that in some cases the potential advantages of mine mechanisation cannot be realised fully unless supplemented by coal washing. Among advantages obtained by the use of coke from washed coal were an increase of 8 per cent. in daily production of pig, a decrease of 8 per cent. in net furnace coke consumption, a decrease of 20 per cent. in flux consumption, and 15 per cent. in slag volume, and a pronounced improvement in the regularity of pig iron analysis. Besides this, there was an increase of 3 per cent. in the yield of furnace coke. This last result, combined with the reduction in coke per ton of iron, means that less mined coal is required per ton of iron. There was little difference in the amount of flue dust produced. Coke oven gas contained 20 per cent. less sulphur. Tuyère losses were less, and the use of coke from washed coal permitted furnace operation with a degree of freedom from irregularity impossible of attainment with coke from the unwashed coals.

A Survey of Plastics*

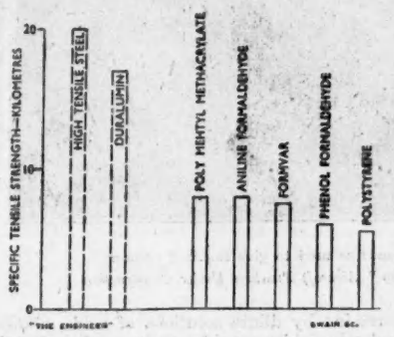
By S. LIVINGSTON SMITH, D.Sc. (Eng.), M.I. Mech. E.†

(*Continued from page 492, December 17th*)

II.—SURVEY OF PLASTIC PRODUCTS (*continued*)

(4) *Mouldings Containing Unidirectional Fibres.*—One of the main objectives of plastics research is to devise means of utilising the high specific strength of cellulose fibres. As the strength of ordinary paper cannot exceed one-third of the strength of the fibres of which it is made, and fabric obviously not more than one-half and with normal twist, and crimp even less, laminated sheets of paper or fabric can never utilise to the full these high specific strengths.

Fig. 3 (derived from data supplied by the Department of Textile Industry, Leeds University) shows the specific tensile strength of



Specific strength in kilometres = 1·57 × strength in tons per square inch ÷ density in grammes per cubic centimetre

FIG. 3—*Specific Tensile Strength of Various Fibres*

various fibres. If means can be evolved to fabricate structures so that the fibres can be made to lie in the direction of the principal stresses, very efficient structures may result.

"Gordon Aerolite," as developed by Dr. N. A. de Bruyne, of Aero Research, Ltd., consists of phenol formaldehyde resin with unwoven linen filler. The flax fibres are not crimped and only very slightly twisted, but in general form and appearance the material is similar to laminated sheet. Some of the properties of this material are given in Table VI in comparison with stainless steel and aluminium alloy.

TABLE VI.—*Properties of Sheet Containing Uniaxial Flax Fibres Compared with Steel and Aluminium Alloy*

Resin content, approximately 25 per cent.

	"Gordon Aerolite."	Stainless steel.	Aluminium alloy.
Density, grammes per cubic centimetre	1·47	7·85	2·8
Tensile strength parallel to laminations :			
Tons per square inch ...	30	80	30
Kilometres	32	16	17
Compressive strength, tons per square inch :			
Parallel to fibres	13	—	—
At 90 deg. to fibres ...	0·2	—	—
Shear strength parallel to fibres :			
Tons per square inch ...	2·45	50	18
Kilometres	2·62	10·1	10·1
Young's modulus :			
Pounds per square inch...	7×10^6	30×10^6	10×10^6
Kilometres	3330	2680	2540

Thus the strength/weight value of "Gordon Aerolite" in one direction is higher than aluminium alloy or high-tensile steel, although allowance must be made for its reduced strength under prolonged loading and for its low fatigue strength.

The obvious application of this uniaxial fibre material is to members subjected simply to tensile stresses, but it is not in the best form to transmit any other type of stresses, except possible direct compressive loads over long distances, *e.g.*, stringers or spar flanges in aircraft. In any other application its low shear strength parallel to the fibres must very seriously restrict its possibilities. It is possible that the shear strength of this material might be improved by orienting some of the flax fibres themselves at 45 deg. to provide shear strength. If this were done, the shear strength might be raised to any desired extent at the expense of a comparable reduction in tensile strength, but no improvement of shear adhesion between the plies would be obtained as this depends primarily on the resin. Thus, whilst the suitability of the material to carry actual tensile and shear stress systems might thereby be improved, the restriction on compressive strength due to low shear adhesion between the plies would still constitute a serious drawback.

Some experiments were carried out at Teddington with the object of securing comparative data for the strength of yarns of different fibres when moulded. Mouldings were prepared in the form of simple eye-ended pieces (Fig. 4*b*) by winding impregnated thread round

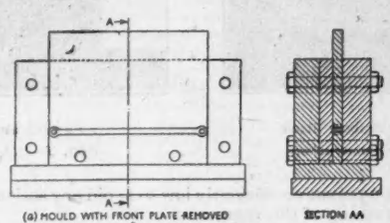


FIG. 4—*Mould and Eye-Ended Pieces for Testing Strength of Yarns*

a bobbin and pressing in the mould shown in Fig. 4*a*. The moulding conditions were 4000 lb. per square inch at 145 deg. Cent. for sixty minutes. Typical properties of linen and cotton yarns moulded in this way are given in Table VII.

TABLE VII.—*Typical Properties of Moulded Linen and Cotton Threads*

Yarn.	Linen.	Cotton.
Tensile strength in parallel portion, tons per square inch ...	22–25	... 20
Shear strength, tons per square inch	1·0–1·5	... —
Compressive strength, tons per inch	12	... 16
Young's modulus in tension, pounds per square inch × 10^6...	3–4	... 9

Fig. 5 shows an elevator control lever, produced commercially by a similar process, which was tested at the Royal Aircraft Establishment, Farnborough. When tested, a load of 1000 lb. —four times the design load—was applied to the end of the lever without any sign of distress. Test pieces cut from the lever gave tensile strengths of 18·1 tons per square inch and compression strengths of 9·25 tons per square inch.

(5) *The Use of Plastics in Combination with Wood.*—The marriage of the new synthetic resins with wood, one of the oldest materials known to the engineer, has given the latter a new lease of life for engineering purposes and, in addition to permitting more economical use of timber, has rendered it suitable for new uses.

(*a*) *Resin-Bonded Plywood.*—Plywood in which the veneers are bonded together by synthetic resin is water-resistant to a degree unknown in earlier plywood (*e.g.*, one current specification calls for resistance to three hours' boil); it can therefore be utilised in the construction of aircraft, boats, &c.

Synthetic resins may be used in two ways, as film glues or as liquid glues. Film glue ("Tego") consists of a very thin paper which has been impregnated with a phenol or cresol formaldehyde resin. The paper acts merely as a vehicle for the resin, the weight of the latter being twice the weight of the paper. In the manufacture of plywood, alternate sheets of veneer and film glue are placed in a low-pressure multiple daylight press, while the resin is cured by heat supplied through the steam-heated platens of the press. The liquid glues—urea formaldehyde is the resin most commonly used—may also be cured in a heated press; alternatively, a catalyst or hardener may be used to allow the glue to set at lower temperatures.

Veneers in conjunction with film or liquid glues may also be used to fabricate complicated shapes in the form of moulded plywood. A certain amount of "tailoring" of the veneers is usually necessary, and an autoclave and some form of flexible membrane is required.

Some typical properties of resin-film bonded birch plywood are given in Table VIII.

TABLE VIII.—*Approximate Properties of Resin-Bonded Birch Plywood, ⅛in. Thick.*

Density, grammes per cubic centimetre	0·65–0·75
Tensile strength parallel to grain of face veneer, tons per square inch	6–7
Young's modulus parallel to grain of face veneers, pounds per square inch	1×10^6–$1·5\times10^6$
Modulus of rigidity, pounds per square inch :	
Grain at 45 deg. to shearing forces	$0·3\times10^6$–$0·4\times10^6$
Grain parallel to shearing forces	$0·2\times10^6$–$0·3\times10^6$
Shear strength, tons per square inch :	
Grain at 45 deg. to shearing forces	2–3
Grain parallel to shearing forces	1·0–1·5

One of the reasons for the temporary superseding of wood by metal in the construction of aircraft was the poor resistance to water of the plywoods then used. The advent of resin-

FIG. 5—*Cord-Reinforced Elevator Control Lever*

bonded plywood has led to a partial reversion to wooden aircraft with a consequent easing of the problem of aircraft production. For example, the fuselage of the "Mosquito" aircraft consists of a sandwich, the inner and outer skins of which are resin-bonded birch plywood and the centre or "meat" of the sandwich consists of the very light balsa wood. Thus, while essentially a wooden aircraft, the "Mosquito" is made possible by the plastics industry in the provision of film-bonded plywood for the skins and synthetic resin glues for securing them to the balsa core. Figs. 6 and 7 show "Mosquitoes" in course of construction.

(*b*) *Compressed and Impregnated Laminated Woods.*—The specific tensile strength of an average wood is about equal to that of duralumin, but as an engineering material it suffers from the following disadvantages which restrict it to secondary or temporary uses :—

(i) It is liable to swell and shrink as a result of moisture absorption.

(ii) It cannot be easily formed to shape, and shaped components have to be machined from the solid tree so that grain and stress directions cannot always be made to correspond.

(iii) It is very weak in shear parallel to the grain, so that stress-carrying connections are bulky and difficult to design.

(iv) It is weak and lacks stiffness at right angles to the grain.

(v) It is variable and subject to frequent defects, such as knots.

Most of these objections are minimised when

* Institution of Mechnical Engineers, December 10th, Abstract.

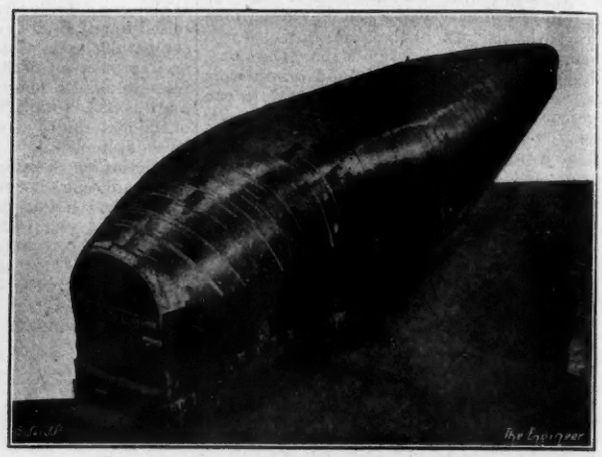
† Superintetdent, Engineering Department, Nat'onal Physical Laboratory.

wood is used in laminated form and, when logs are cut into veneers by peeling, the absence of waste as sawdust is an additional advantage.

The veneers may vary in thickness from $^1/_{200}$in. up to $^1/_{10}$in. There are many variations in this process. The quantity of resin, the method of application, the original thickness of the veneers, and the amount of compression will all affect the final product which may have the appearance of the original timber. On the other hand, the paper is provided merely as a vehicle for the resin and the proportion of paper fibres present is not sufficient to affect the strength of a board. Were normal impregnated papers used to form a composite plastic-wood material, the strength contribution of the paper would be low unless high pressure and resin content were used with a consequently high density product. However, by using high-density impregnated paper the plastic component may be completely bonded

Inner plywood skin in position, between skin members fitted.

FIG. 6—*"Mosquito" Aircraft Fuselage Under Construction*

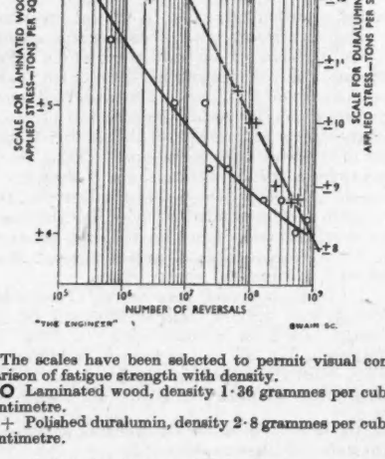


Flexible steel bands as used to give required pressure.

FIG. 7—*"Mosquito" Aircraft Fuselage Under Construction*

the amount of resin and the pressure used may have been so high as to cause all the interstices in the wood to be filled up with resin, resulting in a dense hard product more like metal than wood.

A particularly interesting application is to airscrews. Certain of the stresses in an airscrew arise from centrifugal force, and this can be minimised by arranging strong and therefore dense material near the hub and by causing density to diminish from the hub to the tip of a


SCALE FOR LAMINATED WOOD APPLIED STRESS—TONS PER SQ. IN.
SCALE FOR DURALUMIN APPLIED STRESS—TONS PER SQ. IN.
NUMBER OF REVERSALS
"THE ENGINEER"
SWAIN SC.

The scales have been selected to permit visual comparison of fatigue strength with density.

O Laminated wood, density 1·36 grammes per cubic centimetre.

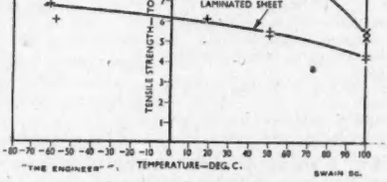
+ Polished duralumin, density 2·8 grammes per cubic centimetre.

FIG. 8—*Rotating Bending Fatigue Tests on Laminated Aircrew Root Material and Duralumin Extended to Endurances of 500,000,000 Cycles*

blade as the need for strength falls off. A variable density airscrew may be made by packing the press more fully with veneers near the root of the blade so that greater pressure and therefore densification takes place there. Another method of making an airscrew is to make the root end of high-density laminated wood and splicing to it lighter natural wood to form the remainder of the blade.

(c) *Wood-Plastic Composites.*—In the film glue at a pressure sufficiently low to avoid any serious crushing of the veneers.

(d) *High-Frequency Heating.*—As heat has to be transmitted to the resin impregnant or interlayers from the platens during production, a limitation to the thickness of laminated woods arises from their low heat conductivity. Therefore boards are seldom produced in thicknesses greater than 2in., and components larger than this are formed by gluing together two or more laminated blocks. Thus the production of laminated woods forms one of the most promising applications of high-frequency heating, in



P.F., phenol formaldehyde.

FIG. 9—*Effect of Temperature on Tensile Strength*

which heat is generated in the interior of the material by dielectric loss.

(e) *Fatigue Resistance of Impregnated Woods.*—Rotating bending fatigue tests carried out on compressed laminated wood of density 85 lb. per cubic foot demonstrate the considerable resistance to fatigue of such material. Fig. 8 shows typical S–N curves relating stress and number of reversals, for laminated wood and duralumin plotted with stress scales which permit visual comparison of fatigue strength in relation to density.

III.—SERVICEABILITY

The applicability of any material in engineering practice depends not only upon its strength properties, but also on its general behaviour under service conditions.

(1) *Effect of Moisture.*—The majority of plastics tend to gain or lose moisture as atmospheric relative humidity varies and this is particularly marked where cellulosic reinforcement is incorporated. As a consequence of sorption of water, dimensions, weight, and mechanical strength will vary and engineers need to give special attention to these factors.

Effect on Strength.—An indication of the possible effect of water on strength and stiffness is given in Table IX.

(2) *Effect of Temperature.*—Fig. 9 shows the effect of temperature on the tensile strength of two commercial grades of laminated sheet.

(3) *Resistance to Corrosion.*—Most plastics, including the formaldehydes, are resistant to corrosion by dilute solutions of acids, alkalis, and salts which would attack metals. Certain plastics, for example, polystyrene, polyethylene,

TABLE IX.—*Effect of Moisture on Mechanical Properties of Paper-Base Laminated Sheet*

Condition.	Equilibrium with 33 per cent. relative humidity.	Equilibrium with 75 per cent. relative humidity.	After immersion in water to constant weight.
Tensile strength, tons per square inch ...	12·6	10·4	7·6
Young's modulus, lb. per square inch $\times 10^6$	2·20	1·98	1·75

and poly-vinyl-chlor-acetate, are resistant to very strong acids.

(To be continued)

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

P.V.C. CABLES FOR USE IN SHIPS

Supplement to No. 883. This Supplement to B.S. 883, Cables for Use on Ships, deals with the use of P.V.C. cables as an alternative to rubber-insulated cables. It follows closely the lines of the Supplement recently issued in connection with B.S. 7, Rubber-Insulated Cables for General Use. The Supplement is contained in P.D. 149, which also sets out a number of amendments to the specification for rubber and paper-insulated cables for use in ships, these changes being necessary to meet the present position regarding the availability of various materials. Price 2s. post free. Purchasers should quote the reference P.D. 149.

SECONDARY ZINC ALLOY FOR DIE CASTING

No. 1141. This war emergency specification has been prepared in order to make use of remelted redundant zinc alloy castings conforming to B.S. 1004. A large tolerance on copper has been allowed and the limits for other impurities, *e.g.*, lead and tin, have been raised above the low limits of B.S. 1004. The initial physical properties of the alloy will vary between those of Alloy A and Alloy B but it is urged that the application should be confined to uses where maintenance of physical properties and dimensional stability are not of primary consequence. Price 1s.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.

The Post-War Marketing of Tin

The Tin Research Institute has the following summary of a report on the post-war marketing of tin, worked out by Mr. John Ireland, Director of the Institute:—The major problem facing the industry, states the report, is to build up an organisation which will create a market sufficiently wide to maintain producers at a reasonable level of activity. This requires a consumption approaching 250,000 tons of tin annually. In financial terms, the pre-war market for, say, £30,000,000 per annum has to be re-established, and over and above this an additional market for upwards of £20,000,000 worth of new tin annually has to be discovered and developed. This is a selling task of considerable magnitude. The report shows that sales depend on the satisfaction of the ultimate consumer, and that where better service can be given, expanded consumption follows. The proposed scheme will harness to the problem of increasing the usefulness of tin the full resources of a modern scientific organisation. This will comprise a nucleus of scientists whose fundamental work will be carried to the stage of practical application by research teams working on a semi-industrial scale under the guidance of committees representing each of the principal tin-consuming industries. An important feature is the establishment of information bureaux in all the important tin-consuming centres throughout the world. These bureaux will be staffed by practical experts ready to go into works and put any tin-consuming process into first-class working order in the light of the most recent scientific knowledge. The experience gained in giving this type of service in Great Britain and on a smaller scale in the United States has proved that there is a widespread need for it, even in these areas where manufacturing technique is highly developed, and in other consuming countries there is even greater scope. The report explains the proposed post-war organisation in detail, and summarises the technical developments already made in all the main fields of consumption. It gives the technical grounds on which are based the reasons for expecting to restore those uses of tin abandoned or curtailed during the present scarcity. The report also indicates some promising new uses arising out of the Institute's researches, and gives quantitative estimates of the increased sales that may be expected as the result of the new organisation's activities at the end of a ten-year period. The budget recommended for these activities is £300,000 per annum, to cover research, development, world-wide technical service, and full supporting publicity. This sum, although much larger than that with which the present organisation has been working, is much less than is devoted to other metals, and is only about 1 per cent. of the gross value of the tin sold annually before the war.

The Pig Iron Market

At the close of the year the trend of the British pig iron market is somewhat uncertain. During the past few weeks the demand for most descriptions of pig iron has become quieter, whilst the increased production has made larger quantities available for consumers. Rather generous allocations have been made to consumers lately, with the exception of hematite pig iron, but, on the other hand, some of the foundries which have been taking large quantities of pig iron have less work in hand. These are principally to be found amongst the engineering and jobbing foundries in which a number of pig iron consuming firms are seeking fresh war work. The volume of business in high-phosphorus pig iron is not sufficient to take care of the production, and some stocks have accumulated. The light castings makers, who are the principal users of this description, are no better employed than they have been for a long time. Low-phosphorus iron is in better supply than it was a few weeks ago, and consumers find little difficulty in obtaining their requirements. Engineering foundries, most of which are employed on making castings for the Government, are big consumers of special irons, and as they have a fair amount of work in hand it is to be supposed that their pig iron requirements will be fairly heavy for a long time to come. There is no shortage, however, of special irons. The production of low and medium-phosphorus iron is on a good scale and the make of refined pig iron has been increased considerably of late. The makers of these pig irons have experienced a drop in the demand, and in some cases are trying to obtain fresh business. The hematite position does not show any great improvement. It is understood that the output has been increased since supplies of high-grade ore from North Africa have been available, but the demand is still considerably in excess of the supply.

Scotland and the North

The iron and steel plants in Scotland are assured of busy working conditions until the end of the year and during the first quarter of 1944. Interest at the moment seems concentrated upon the rush to complete the contracts on the steel makers' books before the end of the year, but it seems certain that there will be a substantial tonnage of orders carried over into 1944. The present position of the steel works is that they are operating under considerable pressure from consumers to obtain deliveries and in a number of cases they have accepted substantial orders for delivery up to the end of the second period of next year. By far the greater part of the production is passing to consumers who have high priority claims, and it is essential that the rate of deliveries to them should be fully maintained. There has been no important change in the characteristics of the demand during the past week or two. The emphasis is upon plates, and large tonnages are passing to the shipyards, heavy engineers, and power plant producers. In this department the steel works are pressed to the limit to meet consumers' requirements, although recently the production has been increased. The demand for sheets also has shown no diminution, and large quantities of these also are passing to the shipyards, whilst the sheet works are so heavily booked that many of them are unable to accept fresh orders except for far-forward delivery. A great deal of the work in hand is for the Government and Service requirements are on a considerable scale. Comparatively little business is passing in heavy sections, but the works producing the lighter sections are fully engaged. Shipyards' requirements of light and special sections are on a particularly heavy scale. There is a strong demand for steel bars of all dimensions, and lately there has been a revival of business in reinforced concrete bars. The engineering industry is absorbing considerable tonnages of heavy bars. The tube works also are actively engaged on contracts that will keep them busy for some time. In the Lancashire market busy conditions prevail, and there is an insistent demand for all kinds of finished steel. New inquiry is also on a substantial scale, and orders have been placed for delivery as far ahead as June next year. Great activity rules at the steel works on the North-West Coast, and there is a tendency for production to increase. Deliveries are on a heavy scale, and the works are pressing to complete the contracts on their books for delivery before the end of the fourth period.

The North-East Coast and Yorkshire

There is a big volume of business on the books of the iron and steel works on the North-East Coast to be completed before the end of the year, and the prospects are that there will be a considerable carry over in the first period of next year. In addition, the works have accepted a considerable tonnage of orders for delivery over the first and second quarters of 1944. There is no doubt that the works have before them a prospect of long and intensive working, but, at the same time, a decline in the demand is noticeable in various departments, and the tendency is for the pressure to lighten in other departments of the industry. It seems to be generally accepted that with the turn of the year the demand will rise again to the proportions which have been experienced during the greater part of the current year. There are, however, some who expect at this stage of the war a lightening in the demand to become a permanent feature of the iron and steel situation. Whatever may have happened in other departments, there has been no relaxation in the volume of business in plates. The situation in this department shows no signs of altering, and the producing works are booked up for months ahead in the majority of cases. The output of semi-finished steel is at a highly satisfactory level, and the consuming industries are obtaining all the blooms, billets, and sheet bars they need. In spite of the great activity ruling at the sheet works there seems to be a surplus of sheet bars, and, as a result, fewer defectives of this description are being used by the re-rollers. Billets are being produced in considerable quantities, and the re-rollers are receiving regular deliveries. The expansion in the demand for structural material appears to have been checked, although there seems to have been no decline in the volume of this material passing into consumption. The call is principally for light sections, and there is a rather poor demand for the heavy sizes. Steel bars of all dimensions are actively taken up by the consuming industries, and there is an important business passing in shafting bars. Steady conditions rule in the Yorkshire iron and steel markets, and this means that the demand for steel products is sufficient to keep all the works busy and to ensure active conditions prevailing in the industry for the first and second quarters of next year. The pressure upon basic steel makers is unchanged, and the works in this department are fully engaged. Similar conditions prevail in the acid carbon steel section, and the resources of the works producing this class of material are being fully taxed. The demand for alloy steel is not so urgent as a few months ago.

The Midlands and South Wales

With the approach of the end of the year, the Midland iron and steel works are making great efforts to complete the contracts on their books for delivery in the fourth period, and, as a result, deliveries have greatly increased. The Christmas holidays will be curtailed at most of the works, as they have been in the past war years, and the opportunity will be taken of undertaking renewals and repairs to plant which has been working under great pressure for some time. The situation of the industry is somewhat different from a year ago, and there is a noticeable easing in the demand in a number of departments. It is believed, however, that this is only a temporary phase, and that, with the commencement of the New Year the demand will revert to its old proportions. In departments, such as the plate, sheet, and, to a lesser degree, light sections, there has been no decline in the intensive demand from consumers, nearly all of whom are engaged on Government work. The plate makers are booked up for some months ahead, and there seems no likelihood of any relaxation of the pressure in the near future. The demand for medium and heavy plates is particularly strong and is spread over a number of consuming industries with the shipyards taking the largest proportion. Sheets are also required by the shipyards in large tonnages, and the contracts on the books of the makers will keep them fully employed well into next year. A considerable proportion of the orders in hand for the Government is for sheets of special finish. There is only a small production of galvanised sheets, as these can only be made by special authorisation, and recently there has been an increase in the demand for painted sheets. The finished iron trade has improved during the past few weeks, and several makers are fully booked until the end of February. The demand is chiefly for best and common bars, but fair quantities of Crown iron are passing into consumption. The makers of iron bars of small sizes are well employed, and the demand for bar iron generally has increased, owing to the difficulty of obtaining early delivery of steel bars. No changes of importance have developed in the South Wales iron and steel industry. There is an active demand for structural steel, but the pressure for billets is not quite so noticeable as a week or two ago. Sheets and tinplate bars, however, are called for in considerable quantities.

Iron and Steel Scrap

The slight improvement in the movement of iron and steel scrap throughout the country appears to have been maintained. The rather better conditions are due to consumers having modified their antipathy towards the lighter and inferior qualities and taking larger supplies. On the other hand, the difficult supply position of good heavy material has shown no sign of improving, although efforts have been made to increase deliveries. Users are in need of much larger quantities of good heavy mild steel scrap cut to furnace and foundry sizes. This material is scarce and any parcels that appear on the market are quickly snapped up. The scarcity of this material has increased the demand for bundled steel scrap and hydraulically compressed steel shearings which are in steady demand to augment the supply of better-class descriptions. There has been some decline in the quantities of mild steel turnings offered, and there is more willingness on the part of consumers to take up parcels of the good heavy and chipped qualities. Mixed wrought iron and steel scrap for basic furnaces is another description, the demand for which has improved considerably, but the pressure to obtain this material is not so keen as in the case of turnings, as supplies are still good. Heavy material, however, is not in plentiful supply, while business in the lighter descriptions is more active and deliveries of this quality have considerably increased. There is also a strong demand for compressed basic bundles, and producers are finding it much easier to dispose of their holdings than for some time. Supplies of cast iron scrap have been increased, and although there is a steady demand the volume of business transacted has been disappointing.

Notes and Memoranda

Rail and Road

CHANGING GAUGE IN SWEDEN.—A number of railway officials in Sweden are at work on the problem of changing the gauges of several Swedish privately owned railways so as to bring them into line with the standard of 4ft. 8½in.

250 MILES A MINUTE.—Britain's mounting strength in men and armaments is exemplified in an L.M.S. announcement which states that its passenger and freight trains now travel over 2,500,000 miles a week, or 250 miles every minute.

SYNTHETIC CYCLE TYRES.—Cycle tyre inner tubes made from synthetic rubber are now being issued, announces the Tyre Manufacturers' Conference. The tubes are marked with the letter "S" and cyclists are advised that they may be repaired with ordinary patches if the surface is first very thoroughly cleaned.

THE RENEWAL OF SLEEPERS.—The U.S.A. railway companies laid more sleepers in their tracks in 1942 than in 1941. Statistics furnished by seventy railways show that in 1942 48,616,240 were laid, compared with 46,875,815 in 1941, an increase of 3·7 per cent. On forty-eight of the lines creosoted or otherwise treated sleepers were laid exclusively. The data quoted cover 332,202 track miles.

RAILWAY GROUPING.—A luncheon took place in London on Wednesday, December 22nd, to celebrate the "coming of age" of the railway amalgamation of January 1st, 1923. Under the Railways Act of 1921, 120 individual railway undertakings were merged into four systems—the Great Western, the London, Midland and Scottish, the London and North-Eastern, and the Southern.

Air and Water

THE FRANKLIN FALLS DAM.—The Franklin Falls dam on the Pemigewasset River was put into service at the end of October. This dam, the construction of which was begun in November, 1939, forms a major link in a chain of flood control reservoirs planned for the Merrimac River basin. It is 130ft. high and 1700ft. long.

A FLOATING DOCK FOR DURBAN.—The decision to build a large floating dock at Durban, capable of handling ships of 16,000 tons, has been announced by the responsible Minister, who inspected the site of the excavation in which the prefabricated parts will be assembled. Graving docks are to be constructed at Cape Town and Port Elizabeth.

A S.A. LIGHTHOUSE.—Green Point lighthouse, the first such beacon to be built on the South African coast, is now 119 years old. Age has so undermined the stability of the old building that structural alterations are being undertaken. The fog siren is being removed from the lighthouse tower and placed next to the sea wall, with its own engine house. No alterations are to be made to the tower itself.

AN INDIAN CANAL SCHEME.—It is reported that plans for constructing new canals and barrages in Sind have been prepared and that the work will start when the dispute regarding the Indus water, between the Punjab and Sind, is settled. The Sind Government is considering, in the first instance, a proposal to construct a new canal in lower Sind to feed the existing canals on the right bank of the Indus in Karachi district.

LLOYD'S REGISTER OF SHIPPING.—The General Committee of Lloyd's Register of Shipping has acceded to the request of Mr. A. J. Barwick, the secretary, to retire at the end of the present year. Mr. Barwick has been in the Society's service for nearly forty-eight years. The Committee has appointed Mr. P. E. Clement, at present assistant secretary, to be acting secretary of the Society as from January 1st, 1944.

A TEN YEARS' PLAN FOR CAPE TOWN.—A ten-year plan for post-war development has been submitted to the Reconstruction Committee of the Cape Town City Council by the city engineer. This will involve an expenditure of £36½ million, consisting of £5·7 million on non-reproductive normal development; £16·3 million on reproductive normal development, excluding electricity works; and £14·5 million on extra-normal development.

AN EGYPTIAN AIR PORT.—The U.S. Air authorities are claiming a great army engineering achievement in the Egyptian desert near Cairo, where one of the world's largest airports, destined for the use of transport aircraft, carrying supplies and personnel to the Far Eastern battle fronts, has been constructed. Known as Payne Field, the base, formerly used by a British reconnaissance squadron, was enlarged in fifty-eight days to accommodate six times its former traffic.

Miscellanea

CHILE TO MAKE MORE CEMENT.—A new cement plant is under construction at Juan Soldado, Chile. The required capital of 40 million pesos has already been oversubscribed.

TURKISH IRON ORE.—Iron ore deposits discovered in 1938 in Divrik, Turkey, have produced 500,000 tons of ore in 3½ years. Half of the output has gone to the Karabuk iron and steel works and 200,000 tons of ore have accumulated at the mine head.

THE MINERAL OUTPUT OF THE U.S.A.—Statistics which close the 1942 record for U.S.A. production of metals and minerals show a new record. The value of all mineral products produced in 1942 reached a total of over 7500 million dollars, exceeding by 8 per cent. the peak year of 1920, when prices were abnormally high, and beating the 1941 level by 10 per cent. All branches of mineral production shared in this achievement.

COLLEGE FOR KIMBERLEY.—Kimberley and the surrounding areas have learned from the S.A. Minister of Education that he has approved in principle of the recognition of the proposed Northern Cape Technical College, which will supersede the existing Griqualand West Technical Institute at Kimberley. The college will be managed by a council of twenty-four. Arrangements are being made to open the college on January 1st, 1944.

THE LATE MR. D. G. SUMNER.—We regret to learn of the sudden death, on December 5th, of Mr. D. G. Sumner, the manager of the Manchester branch of the Reliance Telephone Company, Ltd. (a subsidiary of the G.E.C.). Mr. Sumner was one of the pioneers of telephony and was responsible for some of the largest private telephone installations in this country and abroad, including the first telephone network in Persia installed for the Anglo-Persian Oil Company.

COAL SILT SALVAGE.—An anthracite colliery in Pennsylvania has decided to discontinue the practice of discharging its coal-washing water into a river, a practice of long standing that has brought water supply troubles to cities downstream and recently resulted in court action designed to bring it to an end. A pilot silt salvage plant for experimental purposes installed several months ago at the Lansford Colliery of the Lehigh Coal and Navigation Company has proved so successful that a full-size plant is being erected.

AN X-RAYS RECORD.—The research laboratory of the General Electric Company of America, working on X-rays, has achieved a total potential of 100 million volts for the first time in the history of science. It was obtained from the large induction electron accelerator recently completed. The characteristics of this new type of radiation will be published as soon as they can be determined. The first few observations suffice to show that these characteristics differ radically from those with which physicists are familiar.

A COLORADO DRAINAGE TUNNEL.—It is reported by *Engineering News-Record* that plans are in hand for the construction of a main tunnel, 11,326ft. in length and two laterals totalling 5856ft., to drain the rich Leadville mining district of Colorado. The tunnel, it is claimed, permits the reopening of scores of flooded mines and clears the way for the possible production of 3,000,000 tons of zinc-lead ores and 1,000,000 tons of manganese ores. The workings cover an area of about 8 square miles in Leadville and have been idle since 1933 because of flooding.

RUBBER FROM SOUTH AFRICA.—A project for the production of rubber from the landolphia vine plants in Zululand, which has been under discussion for some time, has not been shelved. Preparatory work is in hand for the establishment of a Government-owned factory under the control of the Director-General of Supplies. Initial research into the yield of this vine has proved sufficiently reassuring to warrant such a step, but the quantity available is definitely limited, and an output of about 400 tons of rubber is anticipated in the course of eighteen months.

THE LATE MR. JAMES LAMONT.—We regret to have to announce that Mr. James Lamont, Midlands representative of G. and J. Weir, Ltd., died on December 13th, at Stockport, after a short illness. Mr. Lamont, who was 64½ years of age, started with the firm in 1905 and had thus been with it for thirty-eight years. He was one of the small band of Weir employees who went out to Persia to erect the Weir oil pumping plant for the Anglo-Persian Oil Company. On his return, after a period as machine shop superintendent at Cathcart, he was sent to New York to open the firm's office in the United States. That office was closed on the outbreak of the last war and Mr. Lamont returned to this country. After representing the firm in Liverpool for some time he made his headquarters at Manchester, and covered the Midlands district for a number of years.

A FRESH USE FOR IRON ORE REFUSE.—A Swedish mining company is enlarging its plant for producing apatite from iron ore refuse. It expects that superphosphate works will be able to make 20,0000 tons a year, the country's minimum requirement.

LIEUT.-COLONEL G. W. PARKINSON.—We regret to announce the death on December 20th, following a road accident, of Lieut.-Colonel George Westhead Parkinson, chairman of Sir Lindsay Parkinson and Co., civil engineering contractors. As well as taking a leading part in the construction of war factories and airfields, Colonel Parkinson was instrumental in bringing to the notice of the Government some of the possibilities of open-cast mining. His comments on this subject, made at the annual meeting of his company last week, are summarised in a "Seven-Day Journal" note on another page.

Personal and Business

MR. W. J. TERRY has been re-elected Chairman of the Cable Makers' Association.

MR. J. W. S. BRANCKER has been appointed traffic director of the British Overseas Airways Corporation.

THE MINISTER OF WAR TRANSPORT has appointed Mr. R. Hugh Roberts to be Regional Port Director for the South-Western Area.

MR. H. G. JORDAN has been appointed managing director of Nissen Buildings, Ltd., in succession to the late Captain W. H. Folkes.

VICKERS LIMITED announce that following the resignation of Colonel J. B. Neilson from the office of deputy chairman, Commander Sir Charles Craven, Bart., R.N., has been appointed deputy chairman of the company as from January 1st, 1944. Colonel Neilson remains on the board of the company.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Bradford Engineering Society

Monday, Jan. 10th.—Technical College, Bradford. "Gears and their Application," W. A. Tuplin. 6.45 p.m.

Institute of Fuel

Thursday, Jan. 6th.—Inst. of Mechanical Engineers, Storey's Gate, S.W.1. "The Heat Content of the Products of Combustion," E. L. Luly. 2.30 p.m.

Institution of Automobile Engineers

Sunday, Jan. 9th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. Address by G. H. Lanchester. 3 p.m.

Institution of Chemical Engineers

Tuesday, Jan. 11th.—Geological Society, Burlington House, Piccadilly, W.1. "The Manufacture of Margarine," A. J. Andersen. 2.30 p.m.

Institution of Electrical Engineers

Wednesday, Jan. 12th.—SCOTTISH CENTRE: Heriot-Watt College, Edinburgh. "The Future of Domestic Wiring Installations," F. Jackson, W. J. H. Wood, G. Smith, and E. Jacobi. 6 p.m.

Institution of Mechanical Engineers

Friday, Dec. 31st.—Storey's Gate, Westminster, S.W.1. "Paints and Protective Finishes for Metals," A. J. Philpot. 5.30 p.m.

Tuesday, Jan. 4th.—S. WALES BRANCH; S. Wales Inst. of Engineers, Park Place, Cardiff. "Gyroscopic Principles and Applications," C. E. Inglis. 3 p.m.

Saturday, Jan. 8th.—WESTERN BRANCH: Physics Dept., The University, Royal Fort, Bristol. "Gyroscopic Principles and Applications," C. E. Inglis. 2.30 p.m.

Keighley Association of Engineers

Friday, Jan. 7th.—Victoria Hotel, Keighley. "A Yorkshire Gentleman, Three Centuries Ago," C. Whone. 7.30 p.m.

Royal Aeronautical Society

Thursday, Jan. 6th.—GRADUATE SECTION: 4, Hamilton Place, W.1. "Technical Problems in the Conversion of Military Aircraft to Civil Use," G. d'Erlanger. 7.30 p.m.

Royal Institution

Tuesday and Thursday, Dec. 28th and 30th.—21, Albemarle Street, W.1. "Vibrations and Waves," E. N. da C. Andrade. 2.30 p.m.

Royal Society of Arts

Wednesday, Jan. 12th.—John Adam Street, Adelphi, W.C.2. "The Story of Petroleum," Sir Frank Smith. 2.30 p.m.